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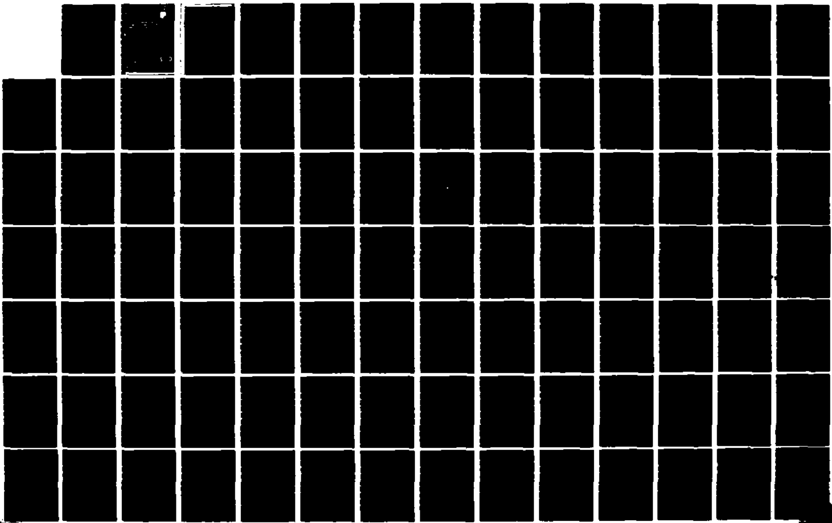

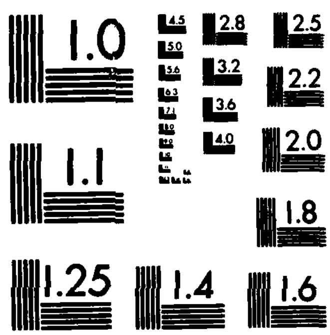

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RADC-TR-83-217, Vol III (of three), Pt 3
Final Technical Report
September 1983

GENERAL ELECTROMAGNETIC MODEL FOR THE ANALYSIS OF COMPLEX SYSTEMS (GEMACS) Computer Code Documentation (Version 3)

The BDM Corporation

Dr. Diana L. Kadlec and Dr. E. L. Coffey

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ROME AIR DEVELOPMENT CENTER
Air Force Systems Command
Griffiss Air Force Base, NY 13441

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Electromagnetic Compatibility
Method of Moments (MOM)
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Antenna Analysis
Matrix Equation Solution
MOM/GTD Hybridization
EM Radiation and Scattering

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

GEMACS solves electromagnetic radiation and scattering problems. The Method of Moments (MOM) and Geometrical Theory of Diffraction (GTD) are used. MOM is formalized with the Electric Field Integral Equation (EFIE) for wires and the Magnetic Field Integral Equation (MFIE) for patches. The code employs both full matrix decomposition and Banded Matrix Iteration (BMI) solution techniques. The MOM, GTD and hybrid MOM/GTD techniques in the code are used to solve electrically small object problems, electrically

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large object problems and combination sized object problems.

Volume I of this report is the User Manual. The code execution requirements, input language and output are discussed.

Volume II is the Engineering Manual. The theory and engineering approximations implemented in the code are discussed. Modeling criterion are given.

Volume III is the Computer Code Documentation Manual. This manual contains extensive software information of the code.

1. NAME: RADCV (GTD)

2. PURPOSE: To compute the longitudinal and transverse radii of curvature of the elliptic cylinder at a given point.

3. METHOD: The longitudinal radius of curvature of the elliptic cylinder (in the plane of incidence) at the point defined by elliptical angle VR (as shown in figure 1) is given by:

$$\rho_g = \frac{(A^2\sin^2 VR + B^2\cos^2 VR)^{3/2}}{AB\ \sin^2\alpha_s} .$$

The transverse radius of curvature at the point defined by elliptical angle VR is given by:

$$\rho_t = \frac{(A^2\sin^2 VR + B^2\cos^2 VR)^{3/2}}{AB\ \sin^2(\alpha_s - \pi/2)} ,$$

where

α_s = SAS
ρ_g = RG
ρ_t = RT.

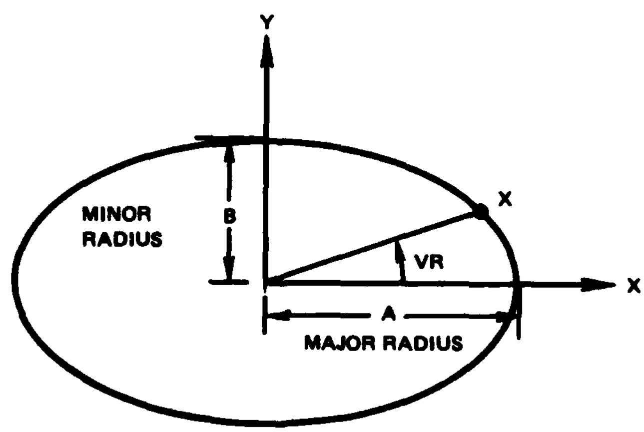


Figure 1. Illustration of Elliptical Cylinder Geometry Used in Computing the Radii of Curvature at Point X

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
A	Cylinder radius along the x axis
B	Cylinder radius along the y axis
RG	Radius of curvature in the plane of incidence
RGT	Radius of curvature of the elliptic cylinder in the principal x-y plane
RT	Radius of curvature transverse to the plane of incidence
SAS	The sine of AS, where AS is π minus THSR (THSR is the theta angle of the observation direction in the reference coordinate system (RCS) relative to the cylinder axis in radians)
SASP	The absolute value of the sine of AS - $\pi/2$, where AS is π minus THSR (THSR is the theta angle of the observation direction in the RCS relative to the cylinder axis in radians)
VR	Elliptic angle defining the desired point on cylinder

5. I/O VARIABLES:

A. INPUT

INPUT	LOCATION
A	/GEOMEL/
B	/GEOMEL/
SAS	/GTD/
SASP	/GTD/
VR	F.P.

B. OUTPUT

OUTPUT	LOCATION
RG	F.P.
RT	F.P.

6. CALLING ROUTINES:

RPLSCL

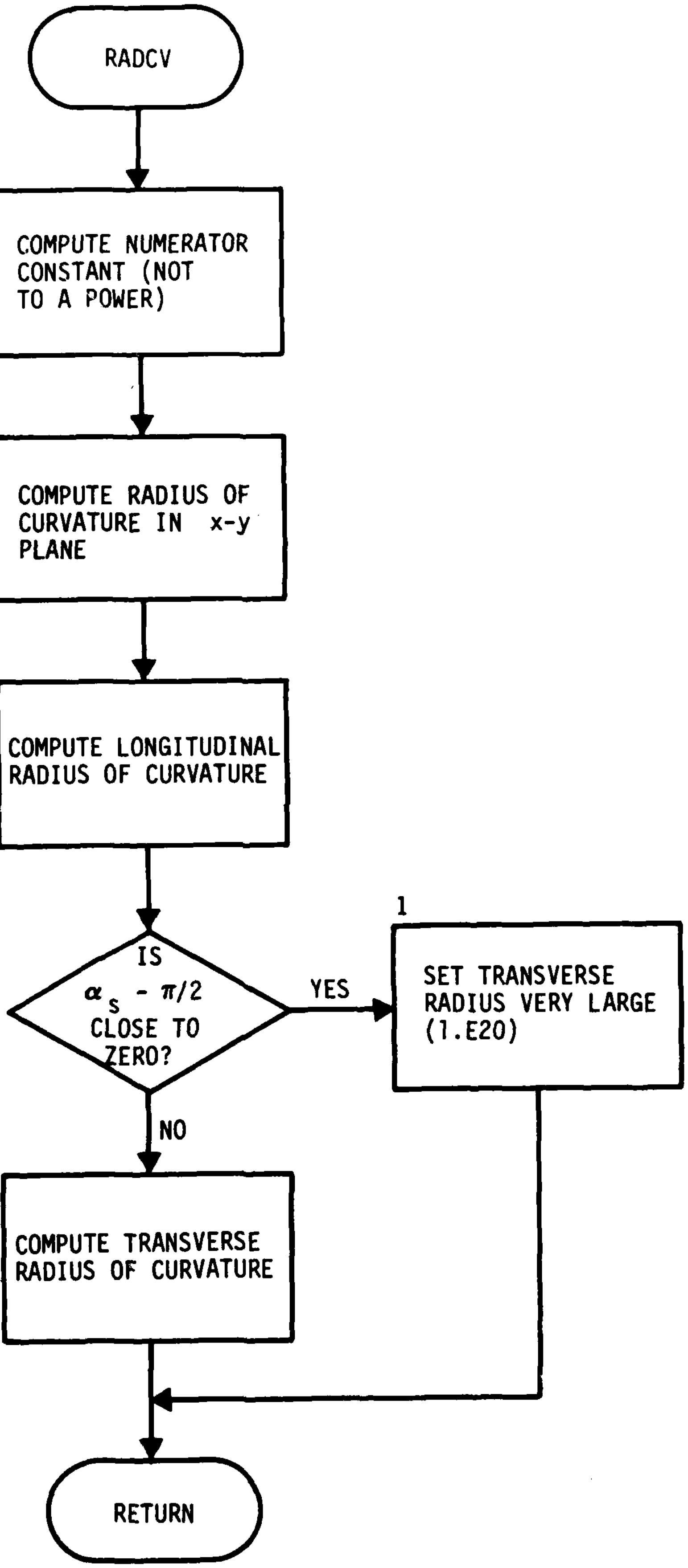
SCLRPL

SCTCYL

7. CALLED ROUTINE:

NONE

RADCV (GTD)


RADCV
COMPUTE NUMERATOR CONSTANT (NOT TO A POWER)
COMPUTE RADIUS OF CURVATURE IN x-y PLANE
COMPUTE LONGITUDINAL RADIUS OF CURVATURE
IS $\alpha_s - \pi/2$ CLOSE TO ZERO?
YES
1
SET TRANSVERSE RADIUS VERY LARGE (1.E20)
NO
COMPUTE TRANSVERSE RADIUS OF CURVATURE
RETURN

1. NAME: RCLDPL (GTD)

2. PURPOSE: To compute the unobstructed electric field from a unit source reflected by a cylinder and diffracted by edge ME of plate MP into the given far-field observation direction or to a given near-field point.

3. METHOD: RCLDPL is the driver routine which directs all the ray tracing, physics and field calculations for determining the electric field from a unit source reflected from a cylinder and then diffracted by a plate in a given far-field direction or to a given near-field observation point. Pertinent geometry is shown in figure 1.

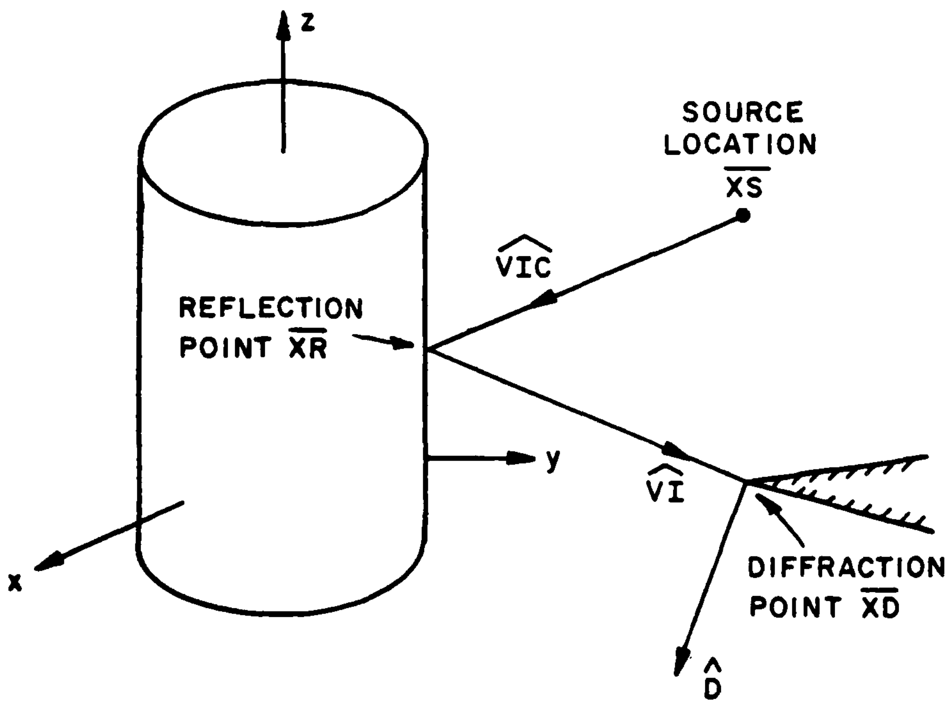


Figure 1. Ray Reflected by Cylinder and then Diffracted by Plate Edge

The code first checks the wedge angle number of edge ME of plate MP. If it is greater than 2, indicating it is part of a wedge, and the edge has already been considered, the fields are set to zero. If

debug information is requested, it is printed on file LUPRNT. Then control is returned to the calling routine. If the wedge angle number is less than 2, the code then checks, for far field only, if diffraction is possible. If it is not possible, a flag is set which indicates that reflection point starting data are not available for the next time RCLDPL is called. The field is set to zero. Debug information (if requested) is printed on file LUPRNT, and control is then returned to the calling routine. This check is not made for near field at this point in the code. Now for both near field and far field subroutine RFDFPT is called. RFDFPT computes the ray path and checks for near-field calculations if diffraction was possible. After returning from RFDFPT, the code makes three checks to determine if reflection and diffraction points are legal. The first check is to make sure that the reflection satisfies Snell's Law. Then the reflection point is checked to make sure it is on the curved surface of the cylinder. The diffraction point is checked to make sure it is on edge ME of the plate. If any of these checks fails, the fields are set to zero, debug information is printed if it was requested, and control is returned to the calling routine. If reflection and diffraction have occurred properly, then the complete ray path is checked for obstructions. If it is obstructed at any location, the fields are set to zero. Debug information is printed if it was requested, and then control returns to the calling routine. If a ray path is unobstructed, the field computations can begin.

The polarization unit vectors for the rays incident and diffracted on the plate and incident and reflected at the cylinder are computed. The source field pattern factor is found by calling subroutine SOURCE. The first field computed is that which is incident on the cylinder. It is computed in components perpendicular and parallel to the plane of incidence. Then the cylinder reflected field is computed. Following this, the field incident on the plate can be computed in parallel and perpendicular components. The caustic distances and ray spreading factors are computed for the reflected-diffracted ray. The phase factor is computed. Diffraction coefficients are found by calling subroutine DW. Now the total diffracted field can be computed and converted to theta and phi components in the reference coordinate system (RCS). Subroutine XYZFLD is called to compute the x, y, and z components of the field and to accumulate them with the fields from other interactions.

If debug information was requested, the total field magnitude is computed. The total field magnitude, and theta and phi components are printed on file LUPRNT. Control is then returned to the calling routine.

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
BO	Diffracted field polarization unit vector parallel to edge
BOP	Incident field polarization unit vector parallel to edge
DD	Normalization constant for cylinder tangent vector
DH	Edge diffraction coefficient for hard field components
DHIT	Distance from source to hit point (from PLAINT)
DOTP	Test parameter used to determine if reflection is legal
DPH	Slope diffraction coefficient for hard boundary condition
DPS	Slope diffraction coefficient for soft boundary condition
DS	Diffraction coefficient for soft field components
DV	Dot product of edge unit vector and diffracted ray propagation direction
EDPH	Phi component of diffracted field in RCS
EDPL	Diffracted field component parallel to edge
EDPR	Diffracted field component perpendicular to edge
EDTH	Theta component of diffracted field in RCS
EF	Theta component of source field pattern factor
EG	Phi component of source field pattern factor

EIPL	Component of field incident on cylinder (or plate) parallel to plane of incidence (or edge)
EIPR	Component of field incident on cylinder (or plate) perpendicular to plane of incidence (or edge)
EIX,EIY,EIZ	Source pattern factors for x,y,z components of incident E-field
ERX,ERY,ERZ	X,Y,Z components of cylinder reflected field in RCS
EXPH	Complex phase and spreading factor
FN	Wedge angle number
FNP	2π minus the wedge angle
GAM	Dot product of vector to the diffraction point with the observation unit vector
LHIT	Set true if ray hits plate (from PLAINT)
LRDC	Set true if reflection data are available from previous pattern angle (or for next pattern angle (when leaving routine))
ME	Edge on plate MP where diffraction occurs
MP	Plate where diffraction occurs
PH	Diffracted field polarization unit vector normal to edge
PHICR	Phi component of field incident on cylinder in RCS
PHO	Incident field polarization unit vector normal to edge
PS	Diffracted ray phi angle in diffraction point coordinate system in degrees
PSOR	Incident ray phi angle in diffraction point coordinate system

PSR	Diffracted ray phi angle in diffraction point coordinate system
RHI1	Caustic distance of cylinder reflected field incident on edge in the direction perpendicular to the edge
RHI2	Caustic distance of cylinder reflected field incident on edge in the direction parallel to the edge
RHIE	Edge caustic distance
RHO1	Ray spreading radius at cylinder in plane normal to plane of incidence
RHO2	Ray spreading radius at cylinder in plane of incidence
SBO	Sine of the diffraction angle
SMAG	Length of ray from reflection point on cylinder to source and distance between reflection and diffraction points
SNF	Distance between diffraction point on plate and near-field observation point
SP	Distance between reflection and diffraction point
THICR	Theta component of incident ray direction on cylinder in RCS
TPP	Distance parameter for edge-diffracted field
UB	Unit binormal of elliptic cylinder at phi angle at which reflection occurs (2-D)
UIPPX,UIPPY,UIPPZ	X,Y,Z components of incident polarization unit vector parallel to plane of incidence
UIPRX,UIPRY,UIPRZ	X,Y,Z components of incident/reflected polarization unit vector perpendicular to plane of incidence
UN	Unit normal of elliptic cylinder at phi angle at which reflection occurs (2-D)

URPPX,URPPY,URPPZ	X,Y,Z components of reflected polarization unit vector parallel to the plane of incidence
VI	X,Y,Z components of ray propagation direction of ray incident on diffraction point
VIC	X,Y,Z components of ray propagation direction of ray incident on cylinder
VR	Elliptical angle defining reflection point on cylinder (2-D)
XD	X,Y,Z components of diffraction point in RCS
XDMAG	Normalization constant for vector from RCS origin to diffraction point
XDP	Modified diffraction point location for shadowing test
X1MAG	Normalization constant for vector from RCS origin to second corner on edge ME
XMAG	Normalization constant for vector from origin to first corner on edge ME
XR	X,Y,Z components of reflection point on cylinder
XRR	Reflection point location on cylinder
XSS	Source location

5. I/O VARIABLES:

A. INPUT	LOCATION
A	/GEOMEL/
B	/GEOMEL/
BCD	/BNDRCL/
CTC	/GEOMEL/
D	/DIR/

DP	/THPHUV/
DPR	/PIS/
DT	/THPHUV/
FLDPT	/NEAR/
FN	F.P.
LDEBUG	/TEST/
LNRFLD	/NEAR/
LRDC	/CLRDC/
LUPRNT	/ADEBUG/
ME	F.P.
MEP	/GEOPLA/
MP	F.P.
PHSR	/DIR/
PI	/PIS/
THSR	/DIR/
TPI	/PIS/
V	/GEOPLA/
VN	/GEOPLA/
VP	/GEOPLA/
VXS	/SORINF/
X	/GEOPLA/
XS	/SORINF/
ZC	/GEOMEL/

B. OUTPUT LOCATION

EDPH	F.P.

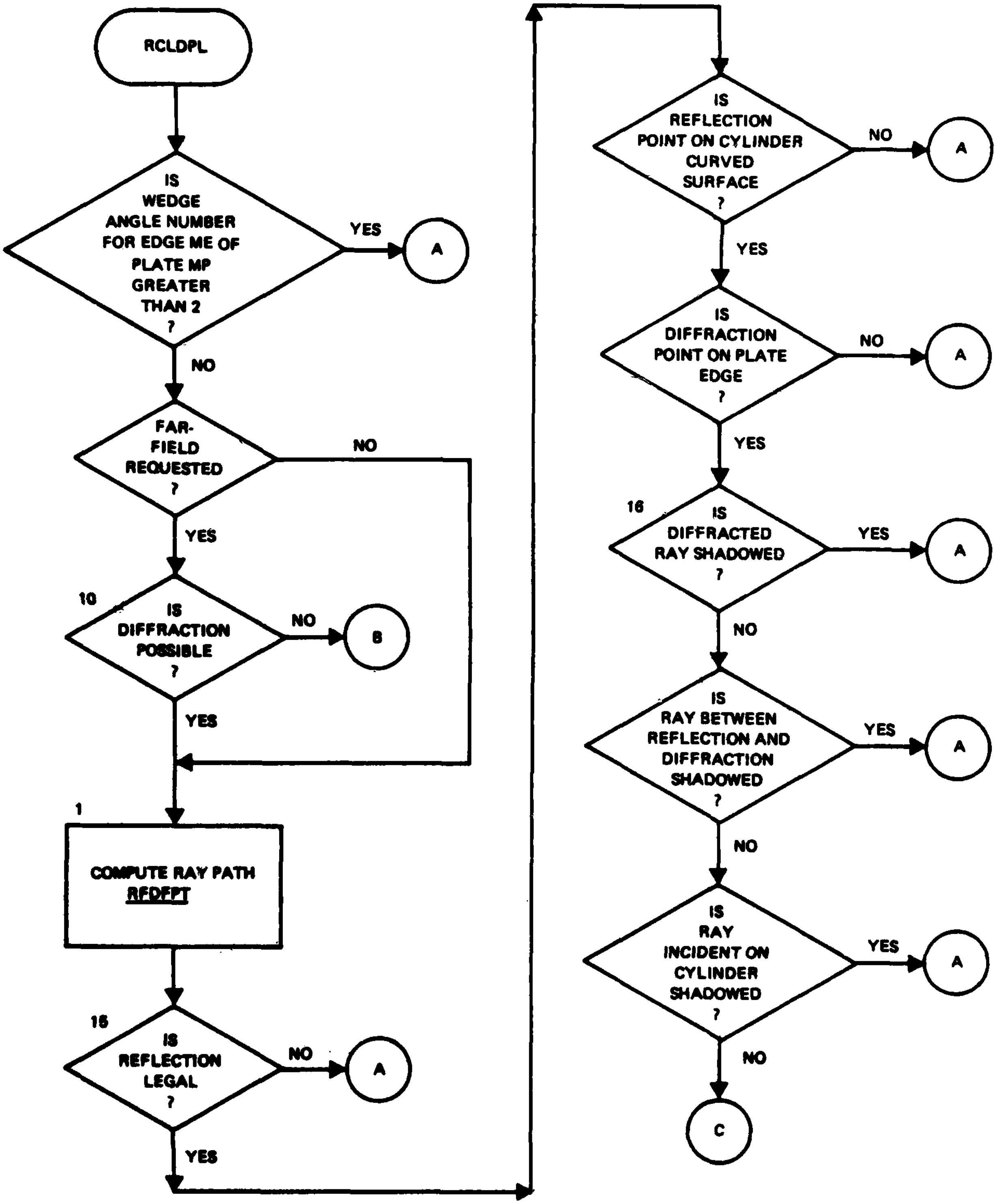
EDTH	F.P.

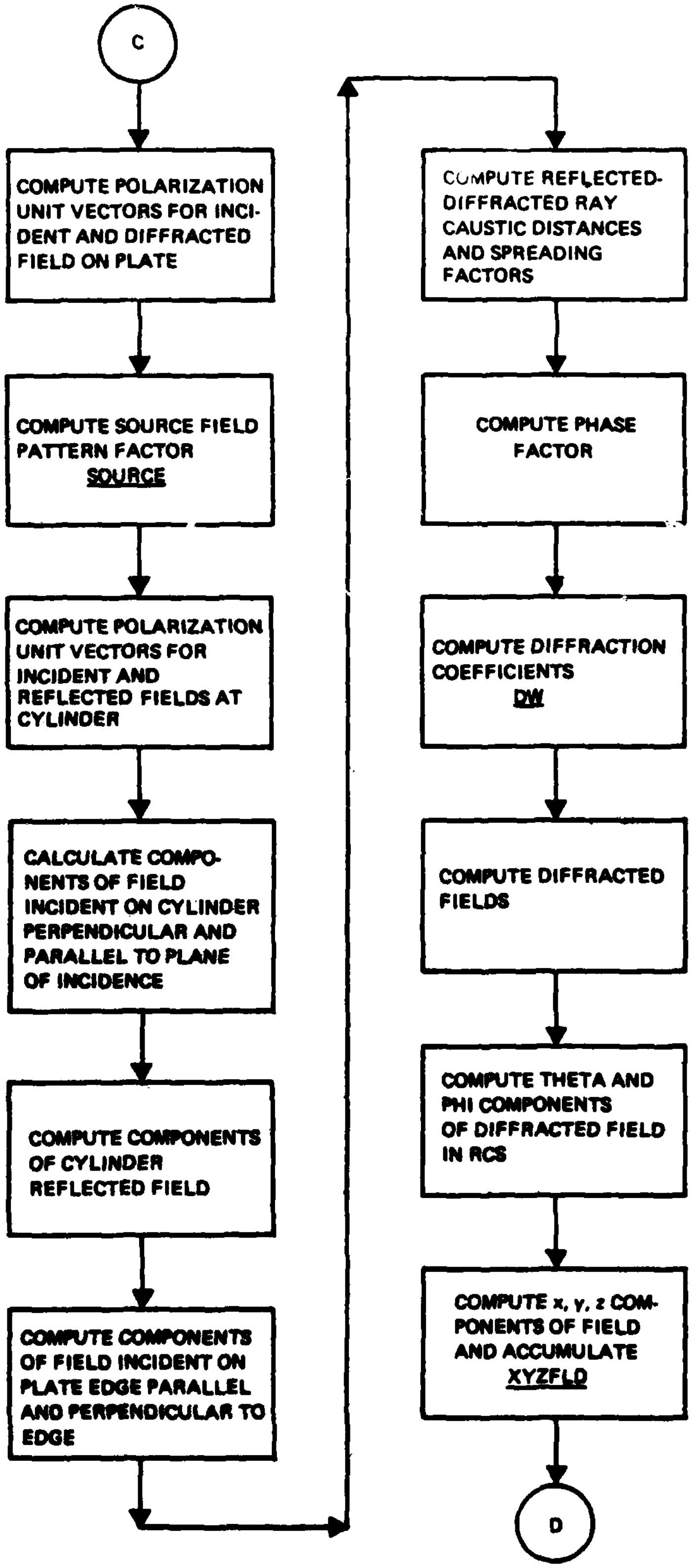
6. CALLING ROUTINE:

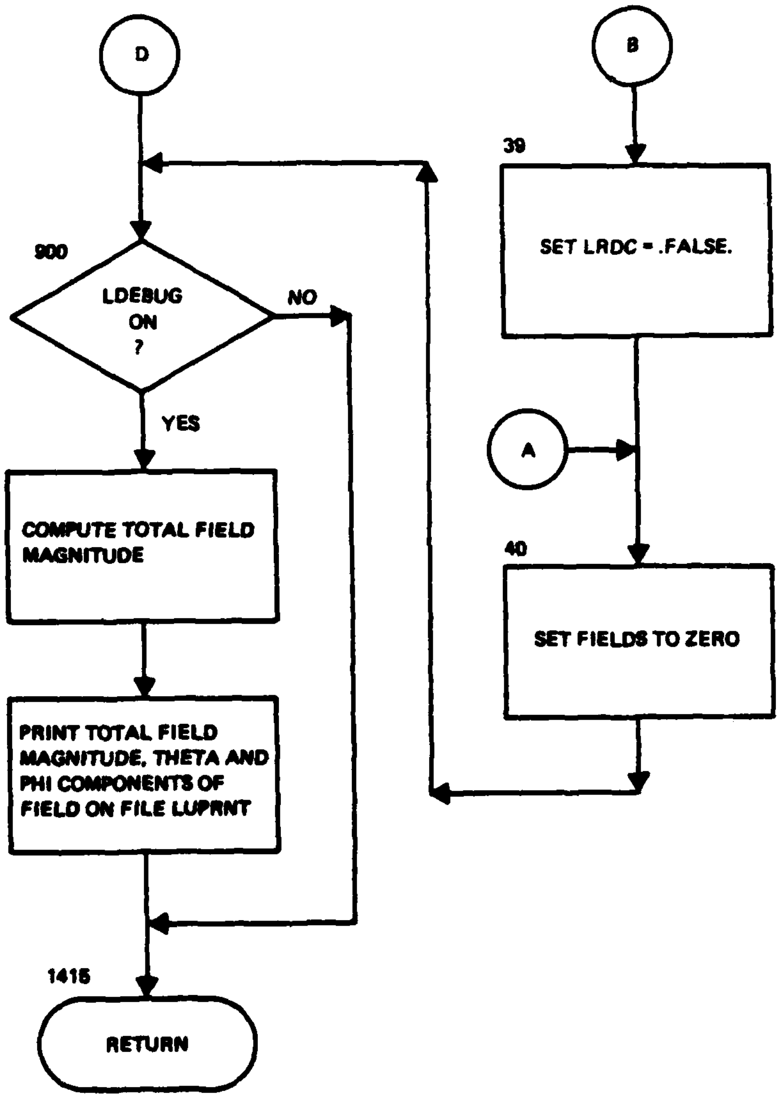
GTDDRV

7. CALLED ROUTINES:

ASSIGN	RFDFPT
BEXP	SMAGNF
BTAN2	SOURCE
CYLINT	STATIN
DW	STATOT
NANDB	TPNFLD
NFD	WLKBCK
PLAINT	XYZFLD


RCLDPL
IS WEDGE ANGLE NUMBER FOR EDGE ME OF PLATE MP GREATER THAN 2 ?
YES
A
NO
FAR-FIELD REQUESTED ?
NO
YES
10
IS DIFFRACTION POSSIBLE ?
NO
B
YES
1
COMPUTE RAY PATH
RFDFPT
15
IS REFLECTION LEGAL ?
NO
A
YES
IS REFLECTION POINT ON CYLINDER CURVED SURFACE ?
NO
A
YES
IS DIFFRACTION POINT ON PLATE EDGE ?
NO
A
YES
16
IS DIFFRACTED RAY SHADOWED ?
YES
A
NO
IS RAY BETWEEN REFLECTION AND DIFFRACTION SHADOWED ?
YES
A
NO
IS RAY INCIDENT ON CYLINDER SHADOWED ?
YES
A
NO
C


C
COMPUTE POLARIZATION UNIT VECTORS FOR INCIDENT AND DIFFRACTED FIELD ON PLATE
COMPUTE SOURCE FIELD PATTERN FACTOR SOURCE
COMPUTE POLARIZATION UNIT VECTORS FOR INCIDENT AND REFLECTED FIELDS AT CYLINDER
CALCULATE COMPONENTS OF FIELD INCIDENT ON CYLINDER PERPENDICULAR AND PARALLEL TO PLANE OF INCIDENCE
COMPUTE COMPONENTS OF CYLINDER REFLECTED FIELD
COMPUTE COMPONENTS OF FIELD INCIDENT ON PLATE EDGE PARALLEL AND PERPENDICULAR TO EDGE
COMPUTE REFLECTED-DIFFRACTED RAY CAUSTIC DISTANCES AND SPREADING FACTORS
COMPUTE PHASE FACTOR
COMPUTE DIFFRACTION COEFFICIENTS DW
COMPUTE DIFFRACTED FIELDS
COMPUTE THETA AND PHI COMPONENTS OF DIFFRACTED FIELD IN RCS
COMPUTE x, y, z COMPONENTS OF FIELD AND ACCUMULATE XYZFLD
D


D
B
39
SET LRDC = .FALSE.
900
LDEBUG
ON
?
NO
YES
A
40
COMPUTE TOTAL FIELD MAGNITUDE
SET FIELDS TO ZERO
PRINT TOTAL FIELD MAGNITUDE, THETA AND PHI COMPONENTS OF FIELD ON FILE LUPRNT
1415
RETURN

1. NAME: RCLRPL (GTD)

2. PURPOSE: To compute the geometrical optics field reflected from the elliptic cylinder and then reflected by plate MP.

3. METHOD: RCLRPL functions as a service routine for subroutine SCLRPL where the total cylinder-plate scattered fields are computed. The field components computed in RCLRPL which are used in SCLRPL are the hard (EHTHJ, EHPHJ) and soft (ESTHJ, ESPHJ) theta and phi components of the source field incident on the cylinder at the reflection point. These components, along with several other useful parameters, are passed to subroutine SCLRPL through common block /FUDGJ/.

The geometrical optics reflected field components ETH and EPH are computed in RCLRPL. These are calculated for the cylinder-reflected, plate-reflected fields from a unit source in the given far-field observation direction or to a given near-field observation point. These components are not used presently. The pertinent geometry for this routine is shown in figure 1.

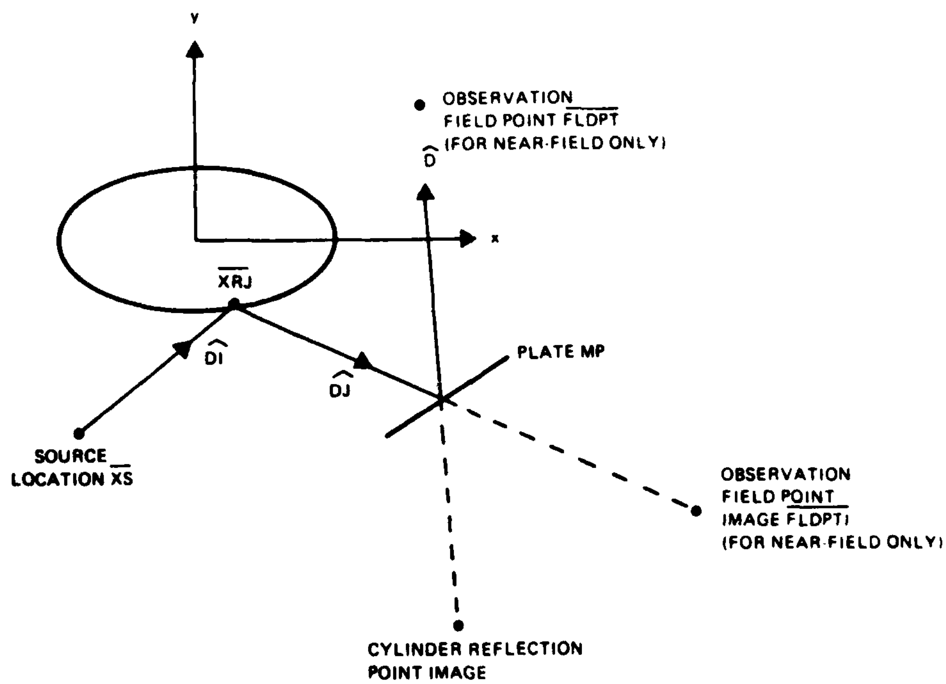


Figure 1. Illustration of Ray Reflected by Cylinder and Then Reflected by Plate.

The code first determines the ray path cylinder and plate reflection points. The procedure followed is different for near-field and far-field calculations. The flowchart shows near-field and far-field paths.

The reflection point on the cylinder is found by imaging the observation direction for far field or the observation point for near field through plate MP. This point is checked to make sure it lies on the cylinder within the end caps. If it does not, the field is set to zero and control is returned to the calling routine. If it is a legal point, the reflection point on the plate is checked to make sure it is a legal point also. If plate reflection did not occur, the field is set to zero and control is returned to the calling routine. If the point is legitimate, the ray path from the source to the cylinder, to the plate, to the far-field observation direction or near-field observation point is checked for shadowing. If the path is shadowed anywnere, again the field is set to zero and control returns to the calling routine. If the path is clear, then at this point it is known that the cylinder-reflected, plate-reflected field does exist.

The physics and field computations begin by computing the source field pattern factor from the source by calling subroutine SOURCE. Then the spreading radii needed FOR including the effect that the curved cylinder wall has on spreading the cylinder-reflected wave is computed. Other parameters, polarization vectors, and image locations are calculated for the field computations. The code computes the fields incident on the cylinder, the cylinder-reflected field and the plate-reflected field. The plate-reflected field's phase factor is based on the cylinder reflection point imaged through plate MP. For far field, this refers the field to the origin of the reference coordinate system. For near field, the phase factor includes the spherical wave spreading factor. The code ends by computing the hard (theta and phi) and soft (theta and phi) components of the field incident on the cylinder.

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
A1, A2	Field components of ray incident on plate, normal and tangent to the plate
A3	Determinant of polarization transformation
C11,C12,C21,C22	Coefficients used to convert polarization from theta and phi components in RCS to components normal and tangent to plate (and vice-versa)
CTHW	2-D dot product of unit normal at cylinder reflection point and ray propagation direction between reflection points

D	Propagation direction after plate reflection in x,y,z RCS components
DD1	Dot product of unit vector of propagation direction and cylinder tangent unit vector through tangent point 1 (2-D)
DD2	Dot product of unit vector of propagation direction and cylinder tangent unit vector through tangent point 2 (2-D)
DHIT	Distance from source to hit point (from PLAINT)
DHJT	Distance between cylinder and plate reflection point (from subroutine PLAINT)
DHT	Distance to hit point (from PLAINT and CYLINT)
DI	X,Y, and Z components of incident ray direction on cylinder in RCS
DJ	X,Y,Z components of propagation direction of ray incident on plate
DMAG	Distance between plate reflection point and near-field observation point
DOTP	Test variable
DP	Phi unit vector for observation direction D
DT	Theta unit vector for observation direction D
EF	Pattern factor of theta component of incident field in RCS (also theta component of cylinder-reflected field in RCS)
EG	Pattern factor of phi component of incident field in RCS (also phi component of cylinder-reflected field in RCS)
EHPHJ	Phi component of hard component of field incident on cylinder
EHTHJ	Theta component of hard component of field incident on cylinder (parallel to plane of incedence)

EIPP	Incident field component parallel to plane of incidence on cylinder
EIPR	Incident field component perpendicular to plane of incidence on cylinder
EPH	Phi component of total cylinder-reflected, plate-reflected field
ERPP	Component of cylinder-reflected field parallel to plane of incidence
ERPR	Component of cylinder-reflected field perpendicular to plane of incidence
ERX, ERY, ERZ	X,Y,Z components of cylinder-reflected field in RCS
ESPHJ	Phi component of soft component of field incident on cylinder
ESTHJ	Theta component of soft component of field incident on cylinder
ETH	Theta component of total cylinder-reflected, plate-reflected field
EX, EY, EZ	X,Y,Z components of source field pattern factor in RCS
FLDPTI	X,Y,Z components of the location of the near-field observation point image through plate MP
GAM	Phase constant
LHIT	Set true if ray hits plate (from PLAINT)
LRFS	Set true if reflection data is available from previous pattern angle (or for next pattern angle (when leaving routine))
LTRFJ	Set true if geometrical optics reflected-reflected fields do not exist
MP	Plate on which reflection occurs after cylinder reflection
PH	Complex phase constant

PHIR	Phi component of incident ray direction on cylinder in RCS
PHJR	Phi component of ray propagation direction between cylinder and plate in RCS
RGJ	Radius of curvature of cylinder at reflection point
RHO1J	Ray spreading radius in plane of cylinder curvature at reflection point
RHO2	Ray spreading radius in plane normal to plane of incidence at reflection point
S1	Distance between reflection points on cylinder and plate
S2	Distance between cylinder reflection point and near-field observation point image through plate MP (therefore distance of complete ray path between reflection point on cylinder and the near-field observation point)
SMAGJ	Length of ray from reflection point on cylinder to source
SNFF	Distance from plate reflection point to near-field observation point
SXN, SYN, SZN	X,Y,Z components of unit vector of ray from reflection point on cylinder to source location in RCS
THIR	Theta component of incident ray direction on cylinder
THJR	Theta component of ray propagation direction between cylinder and plate
UB	Unit binormal at the cylinder reflection point
UIPPX,UIPPY,UIPPZ	X,Y,Z components of incident polarization unit vector parallel to plane of incidence

UIPRX,UIPRY,UIPRZ	X,Y,Z components of incident/reflected polarization unit vector perpendicular to plane of incidence
UN	Unit normal at the cylinder reflection point
UR	The z component of the location of the reflection point on the cylinder
URPPX,URPPY,URPPZ	X,Y.Z components of reflected polarization unit vector parallel to plane of incidence
VR	Phi angle used to define the x and y components of the reflection point on cylinder
VT	X, Y, Z components of polarization unit vector tangent to plate and normal to ray incident on plate
VXS	Matrix defining source coordinate system axes in RCS components
XRJ	X, Y, Z components of reflection point location on cylinder
XRR	Cylinder reflection point location
XRS	Reflection point on plate (also cylinder reflection point image location in plate) Also cylinder reflection point
XSS	Source location

5. I/O VARIABLES:

A. INPUT — LOCATION

INPUT	LOCATION
A	/GEOMEL/
B	/GEOMEL/
BTS	/BNDSCL/
CTC	/GEOMEL/
D	/DIR/
DP	/THPHUV/

	DT	/THPHUV/
	DTS	/BNDSCL/
	FLDPT	/NEAR/
	LNRFLD	/NEAR/
	LRFS	/CLRFS/
	MP	F.P.
	PHSR	/DIR/
	PI	/PIS/
	THSR	/DIR/
	TPI	/PIS/
	VN	/GEOPLA/
	VXS	/SORINF/
	XS	/SORINF/
	ZC	/GEOMEL/
B.	OUTPUT	LOCATION
	EHPHJ	/FUDGJ/
	EHTHJ	/FUDGJ/
	EPH	F.P.
	ESPHJ	/FUDGJ/
	ESTHJ	/FUDGJ/
	ETH	F.P.
	LRFS	/CLRFS/
	LTRFJ	/FUDGJ/
	RGJ	/FUGDJ/
	RHO1J	/FUDGJ/

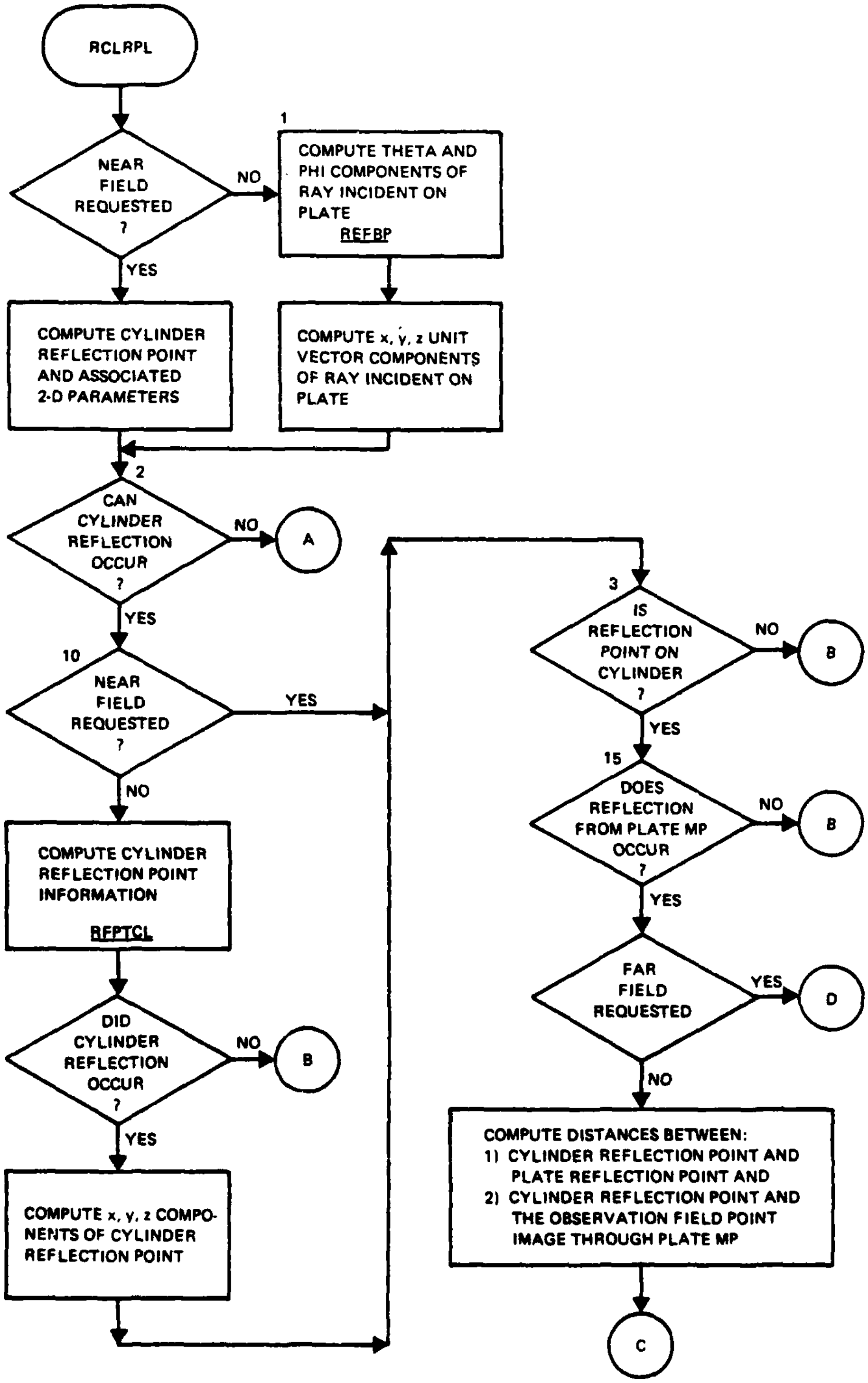
SMAGJ	/FUDGJ/
SNFF	/DIST/
TRANJ	/FUDGJ/
XRJ	/FUDGJ/

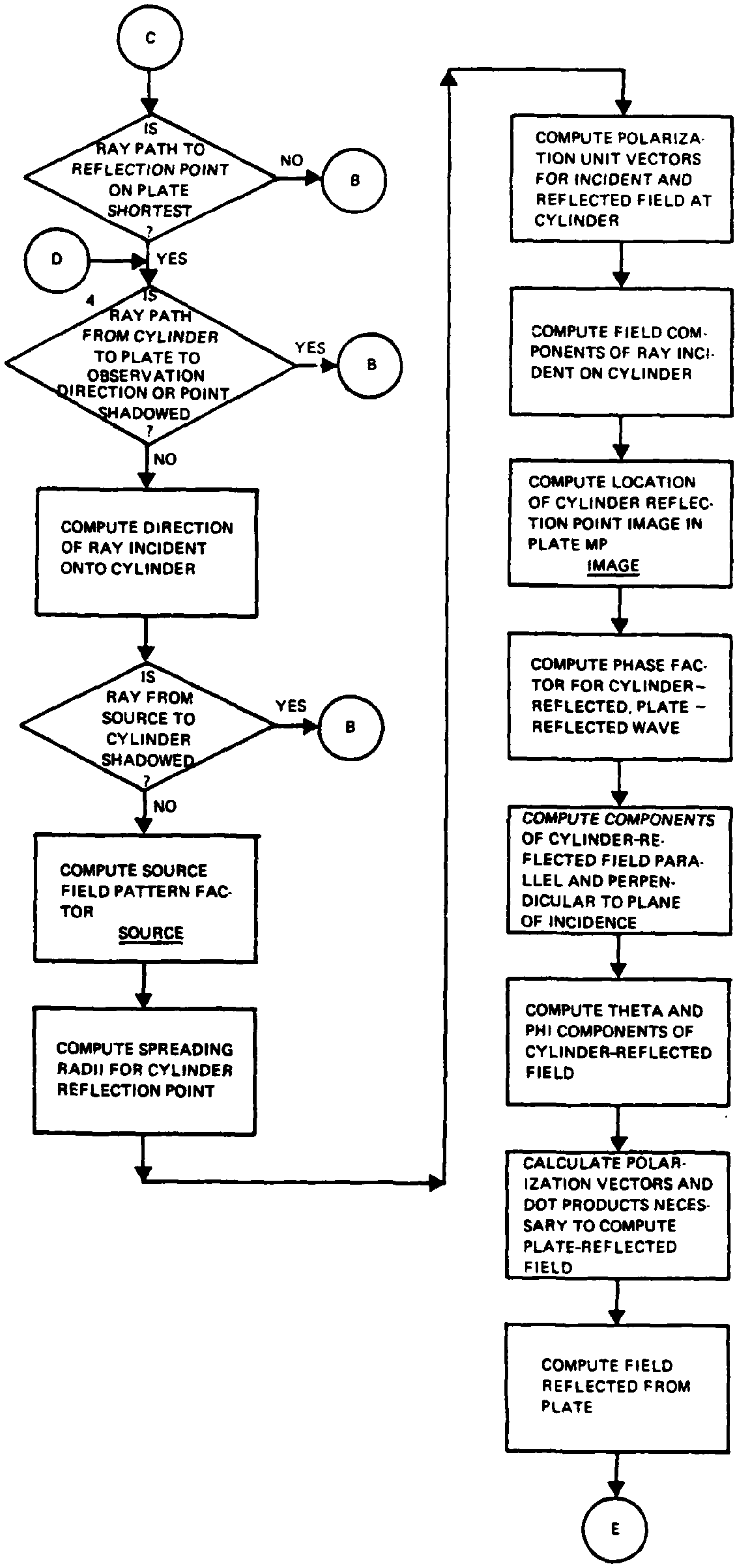
6. CALLING ROUTINE:

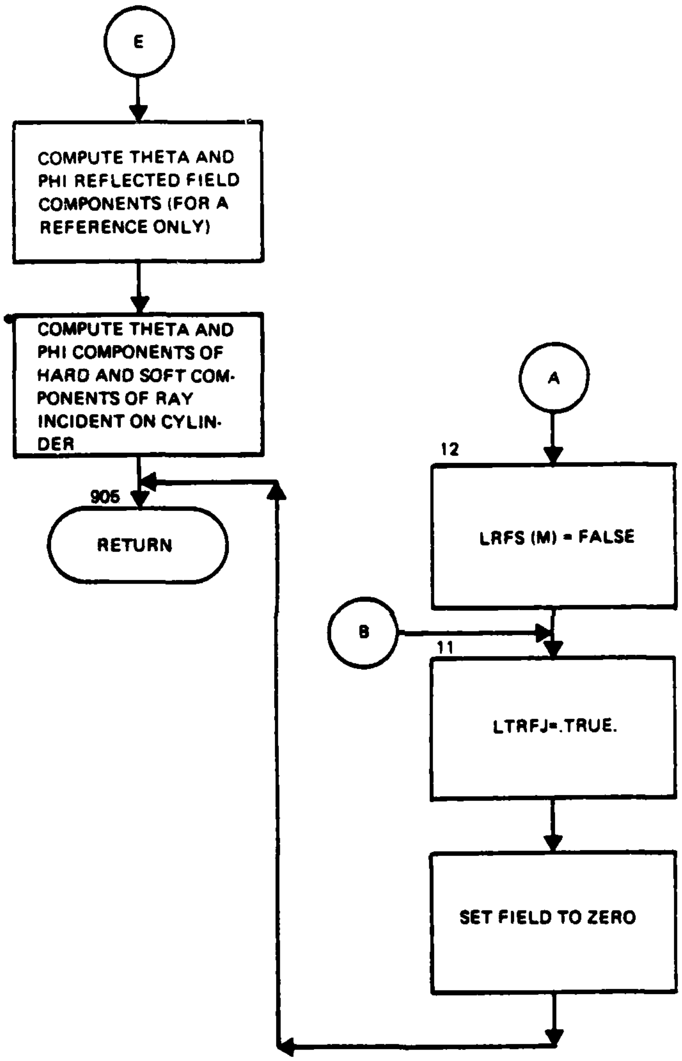
SCLRPL

7. CALLED ROUTINES:

ASSIGN	NFD	SOURCE
BEXP	PLAINT	STATIN
BTAN2	REFBP	STATOT
CYLINT	RFDFIN	TPNFLD
IMAGE	RFPTCL	WLKBCK
NANDB	SMAGNF	


RCLRPL
NEAR FIELD REQUESTED ?
NO
YES
1
COMPUTE THETA AND PHI COMPONENTS OF RAY INCIDENT ON PLATE
REFBP
COMPUTE CYLINDER REFLECTION POINT AND ASSOCIATED 2-D PARAMETERS
COMPUTE x, y, z UNIT VECTOR COMPONENTS OF RAY INCIDENT ON PLATE
2
CAN CYLINDER REFLECTION OCCUR ?
NO
A
YES
10
NEAR FIELD REQUESTED ?
YES
NO
COMPUTE CYLINDER REFLECTION POINT INFORMATION
RFPTCL
DID CYLINDER REFLECTION OCCUR ?
NO
B
YES
COMPUTE x, y, z COMPONENTS OF CYLINDER REFLECTION POINT
3
IS REFLECTION POINT ON CYLINDER ?
NO
B
YES
15
DOES REFLECTION FROM PLATE MP OCCUR ?
NO
B
YES
FAR FIELD REQUESTED
YES
D
NO
COMPUTE DISTANCES BETWEEN:
1) CYLINDER REFLECTION POINT AND PLATE REFLECTION POINT AND
2) CYLINDER REFLECTION POINT AND THE OBSERVATION FIELD POINT IMAGE THROUGH PLATE MP
C


C
IS RAY PATH TO REFLECTION POINT ON PLATE SHORTEST ?
NO
B
D
YES
4
IS RAY PATH FROM CYLINDER TO PLATE TO OBSERVATION DIRECTION OR POINT SHADOWED ?
YES
B
NO
COMPUTE DIRECTION OF RAY INCIDENT ONTO CYLINDER
IS RAY FROM SOURCE TO CYLINDER SHADOWED ?
YES
B
NO
COMPUTE SOURCE FIELD PATTERN FACTOR
SOURCE
COMPUTE SPREADING RADII FOR CYLINDER REFLECTION POINT
COMPUTE POLARIZATION UNIT VECTORS FOR INCIDENT AND REFLECTED FIELD AT CYLINDER
COMPUTE FIELD COMPONENTS OF RAY INCIDENT ON CYLINDER
COMPUTE LOCATION OF CYLINDER REFLECTION POINT IMAGE IN PLATE MP
IMAGE
COMPUTE PHASE FACTOR FOR CYLINDER-REFLECTED, PLATE-REFLECTED WAVE
COMPUTE COMPONENTS OF CYLINDER-REFLECTED FIELD PARALLEL AND PERPENDICULAR TO PLANE OF INCIDENCE
COMPUTE THETA AND PHI COMPONENTS OF CYLINDER-REFLECTED FIELD
CALCULATE POLARIZATION VECTORS AND DOT PRODUCTS NECESSARY TO COMPUTE PLATE-REFLECTED FIELD
COMPUTE FIELD REFLECTED FROM PLATE
E


E
COMPUTE THETA AND PHI REFLECTED FIELD COMPONENTS (FOR A REFERENCE ONLY)
COMPUTE THETA AND PHI COMPONENTS OF HARD AND SOFT COMPONENTS OF RAY INCIDENT ON CYLINDER
905
RETURN
A
12
LRFS (M) = FALSE
B
11
LTRFJ=.TRUE.
SET FIELD TO ZERO

1. NAME: RDEFIL (GTD, INPUT, MOM, OUTPUT)

2. PURPOSE: Read data from the logical unit specified and increment the internal file pointers to indicate the current file position.

3. METHOD: The number of words between the current file position and the end of file is determined and, if less than the number of words requested, a fatal error is generated. Otherwise, the file is read in the binary mode and the current file pointer is incremented to point at the last word read from the file.

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
LUNIT	Input argument designating logical unit to read
NUMLFT	Number of words left before the end of the file from current pointer position
NWORDS	Input argument designating number of words to be read
XWORDS	Input array into which the data will be read

5. I/O VARIABLES:

A.

INPUT	LOCATION
DBGPRT	/ADEBUG/
IOCKPT	/SYSFIL/
IOFILE	/IOFLES/
ISON	/ADEBUG/
LUNIT	F.P.
LUPRNT	/ADEBUG/
MODCHK	/SYSFIL/
NDFILE	/IOFLES/
NWORDS	F.P.

PREVIOUS PAGE IS BLANK

8. OUTPUT	LOCATION
IERRF	/ADEBUG/
IOFILE	/IOFLES/
XWORDS	F.P.

6. CALLING ROUTINES*:

BUBBLE (1)	RESTRT (1)
DECOMP (3)	RWCOMS (1,2,3,4)
GEODRV (1)	RWFILS (1,2,3,4)
GETSYM (1,2,3,4)	SOLDRV (3)
MOVFIL (1,2,3,4)	STRTUP (2,3,4)
PUTSYM (1,2,3,4)	SUBPAT (1)

7. CALLED ROUTINES:

ASSIGN

ERROR

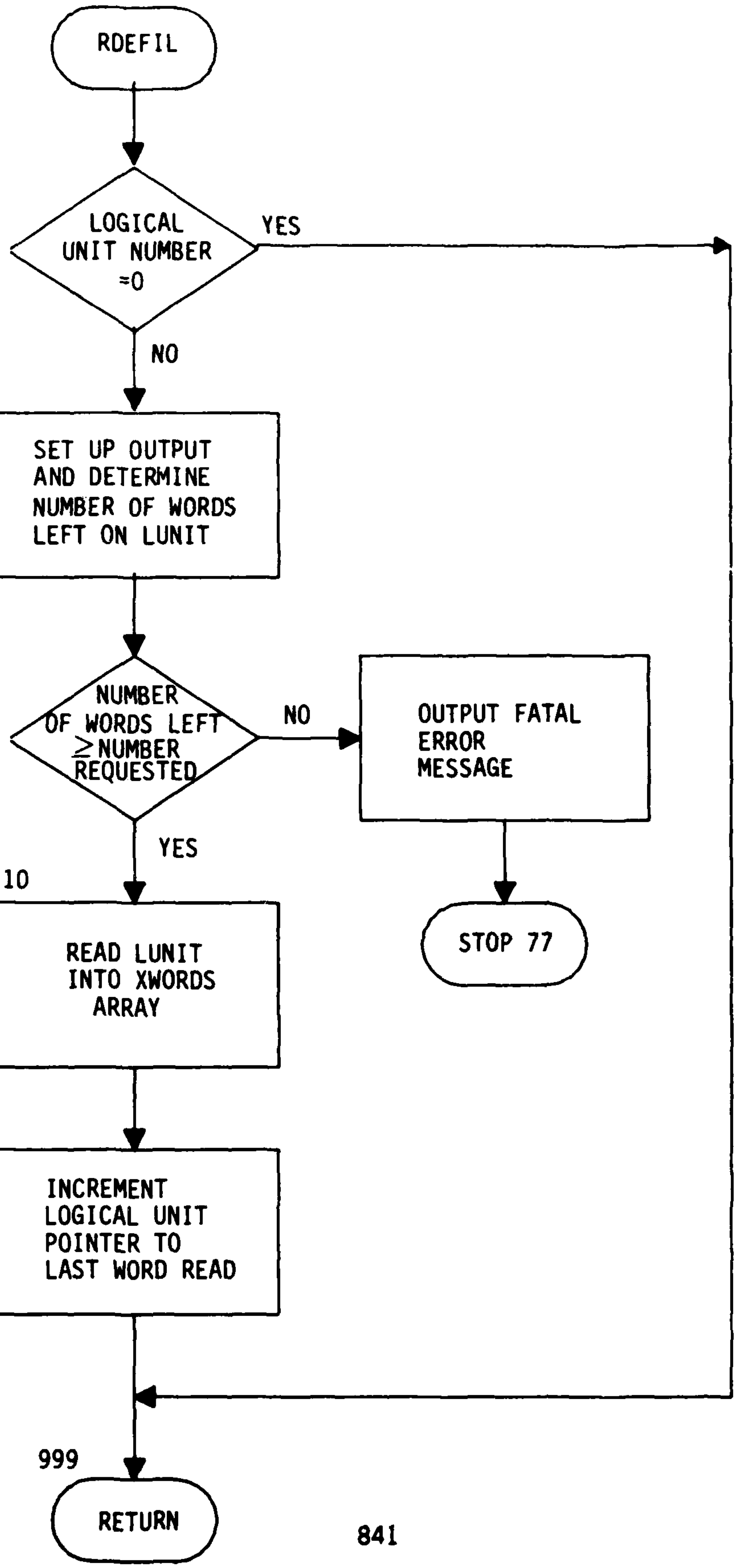
STATIN

STATOT

WLKBCK

*1-INPUT
2-GTD
3-MOM
4-OUTPUT

RDEFIL (GTD, INPUT, MOM, OUTPUT)



1. NAME: REBLCK (MOM)

2. PURPOSE: To reblock the interaction matrix into several square submatrices when structure symmetry is present.

3. METHOD: When structure symmetry is present the full square interaction matrix is not generated. Instead, only an NR x NC matrix is needed, where NC is the number of elements per symmetry cell, and NR is the total number of elements. NR is always an integer multiple of NC, this integer being the number of symmetry cells. Since the matrix problem will be solved in (NC x NC) blocks, the data must be reblocked into that format.

Each column of NC elements is read into core from the input symbol (the matrix is stored in transposed form), and the proper elements stored in the columns of each submatrix of the output data set, as shown in figure 1.

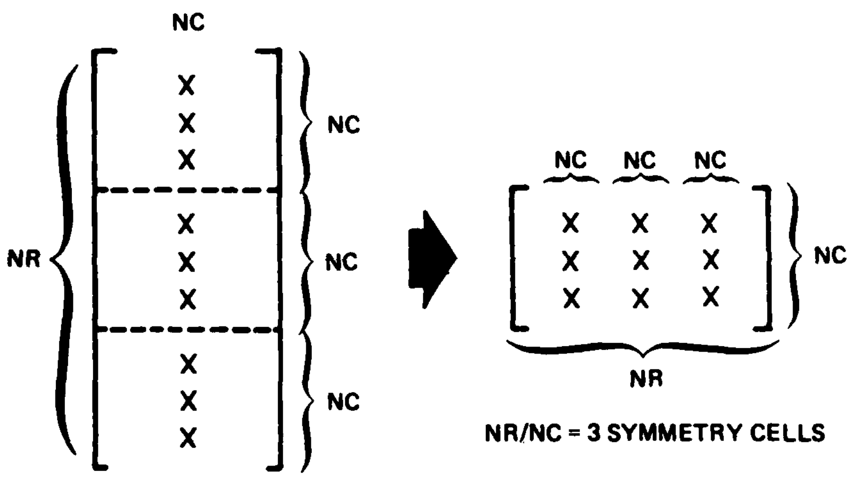


Figure 1. Illustrating the Reblocking of an NRxNC Matrix Into an NCxNR Matrix

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
JNC	Internal variable equal to NC
JREC	Pointer to column number being read from input data set
KREC	Pointer to column number being written to output data set

LOCNAM	Pointer to input data set name in symbol table
MORE	Flag indicating a complex data set
N	Loop index over symbol table entries and submatrices
NAMEZ	User-assigned name of input data set (NR x NC)
NAMEZ1	User-assigned name of output data set (NC x NR)
NBIAS	Pointer to beginning of output for a column of NAMEZ1
NBITS	Attribute word of input data set
NC	Number of columns of input data set
NPRELM	Number of data words per matrix element
NR	Number of rows of input data set
NUMMAT	Number of symmetry cells in input data set; number of submatrices in output data set
Z	Temporary storage for matrix reblocking

5. I/O VARIABLES:

A. INPUT

INPUT	LOCATION
ISON	/ADEBUG/
KBCPLX	/PARTAB/
KOLBIT	/PARTAB/
KOLNAM	/PARTAB/
LUPRNT	/ADEBUG/
NAMEZ	F.P.
NAMEZ1	F.P.
NC	F.P.

NDATBL	/PARTAB/
NPDATA	/PARTAB/
NR	F.P.
Z	F.P.

B. OUTPUT — LOCATION

IERRF	/ADEBUG/
Z	F.P.

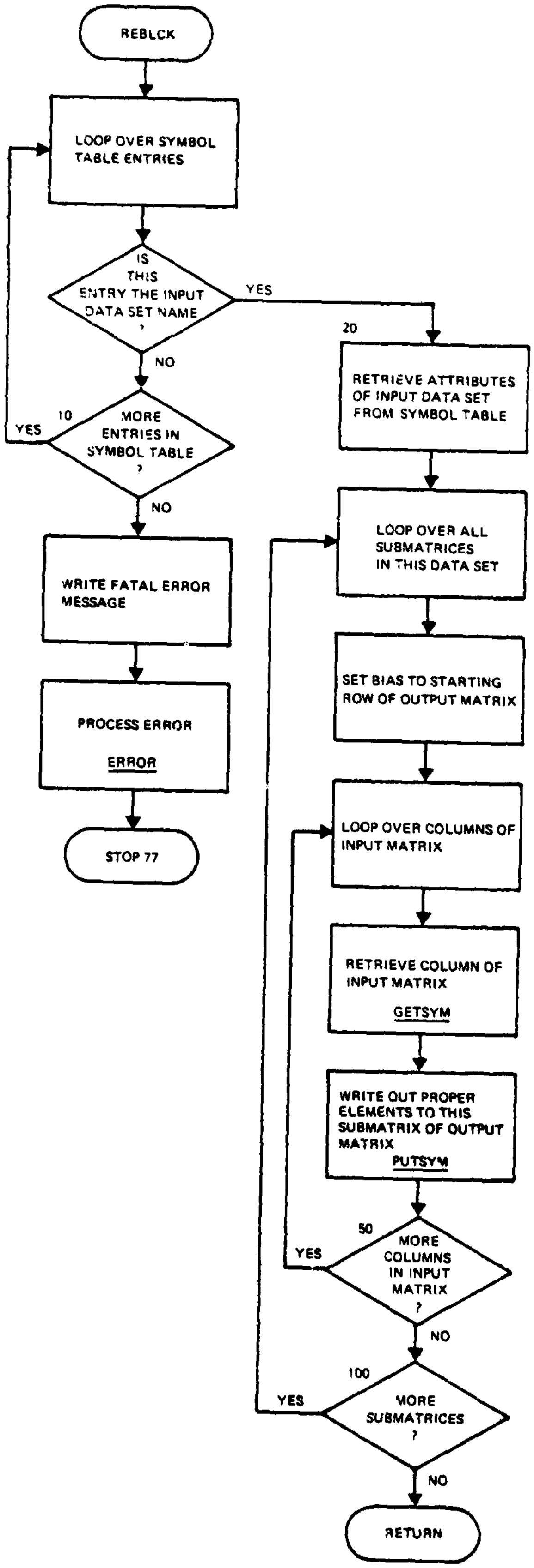
6. CALLING ROUTINE:

ZIJDRV

7. CALLED ROUTINES:

ASSIGN	GETSYM	STATIN
CONVRT	IBITCK	STATOT
ERROR	PUTSYM	WLKBCK

REBLCK (MOM)


REBLCK
LOOP OVER SYMBOL TABLE ENTRIES
IS THIS ENTRY THE INPUT DATA SET NAME ?
YES
NO
20
RETRIEVE ATTRIBUTES OF INPUT DATA SET FROM SYMBOL TABLE
10
MORE ENTRIES IN SYMBOL TABLE ?
YES
NO
WRITE FATAL ERROR MESSAGE
PROCESS ERROR
ERROR
STOP 77
LOOP OVER ALL SUBMATRICES IN THIS DATA SET
SET BIAS TO STARTING ROW OF OUTPUT MATRIX
LOOP OVER COLUMNS OF INPUT MATRIX
RETRIEVE COLUMN OF INPUT MATRIX
GETSYM
WRITE OUT PROPER ELEMENTS TO THIS SUBMATRIX OF OUTPUT MATRIX
PUTSYM
50
MORE COLUMNS IN INPUT MATRIX ?
YES
NO
100
MORE SUBMATRICES ?
YES
NO
RETURN

1. NAME: REFBP (GTD)

2. PURPOSE: To calculate the incident ray direction needed in order to obtain the reflected ray in a given direction from a specified plate.

3. METHOD: The incident ray unit vector (VI) is found by imaging the reflected ray unit vector (DR) through the plate (MP). Figure 1 shows the important geometry. The equation for VI is:

$$\hat{VI} = \hat{DR} - 2(\hat{VN} \cdot \hat{DR})\,\hat{VN}$$

The theta and phi angles which define $\hat{VI}$ are sent back to the calling routine.

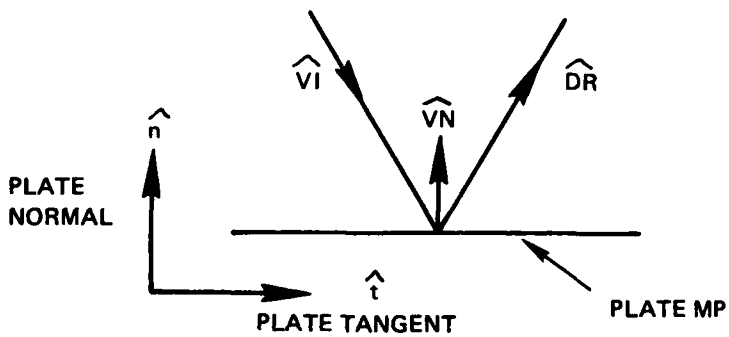


Figure 1. Illustration of Incident and Reflected Rays on Plate

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
CPS	Cosine of PHSR
CTS	Cosine of THSR
DN	Cross product of DR and VN
DR	Reflected ray propagation direction in x,y,z RCS components
ERD	Error detection variable
LUPRNT	File on which warning message will be printed
MP	Plate upon which reflection occurs

PHIR	Phi component of incident ray propagation direction in RCS
PHSR	Phi component of reflected ray propagation direction in RCS
SPS	Sine of PHSR
STS	Sine of THSR
THIR	Theta component of incident ray propagation direction in RCS
THSR	Theta component of reflected ray propagation direction in RCS
VI	X,Y,Z components of incident ray propagation direction in RCS
VIN	Dot product of plate normal and VI
VN	Array which includes unit vector normal to plate MP

5. I/O VARIABLES:

A. INPUT	LOCATION
LUPRNT	/ADEBUG/
MP	F.P.
PHSR	F.P.
THSR	F.P.
VN	/GEOPLA/

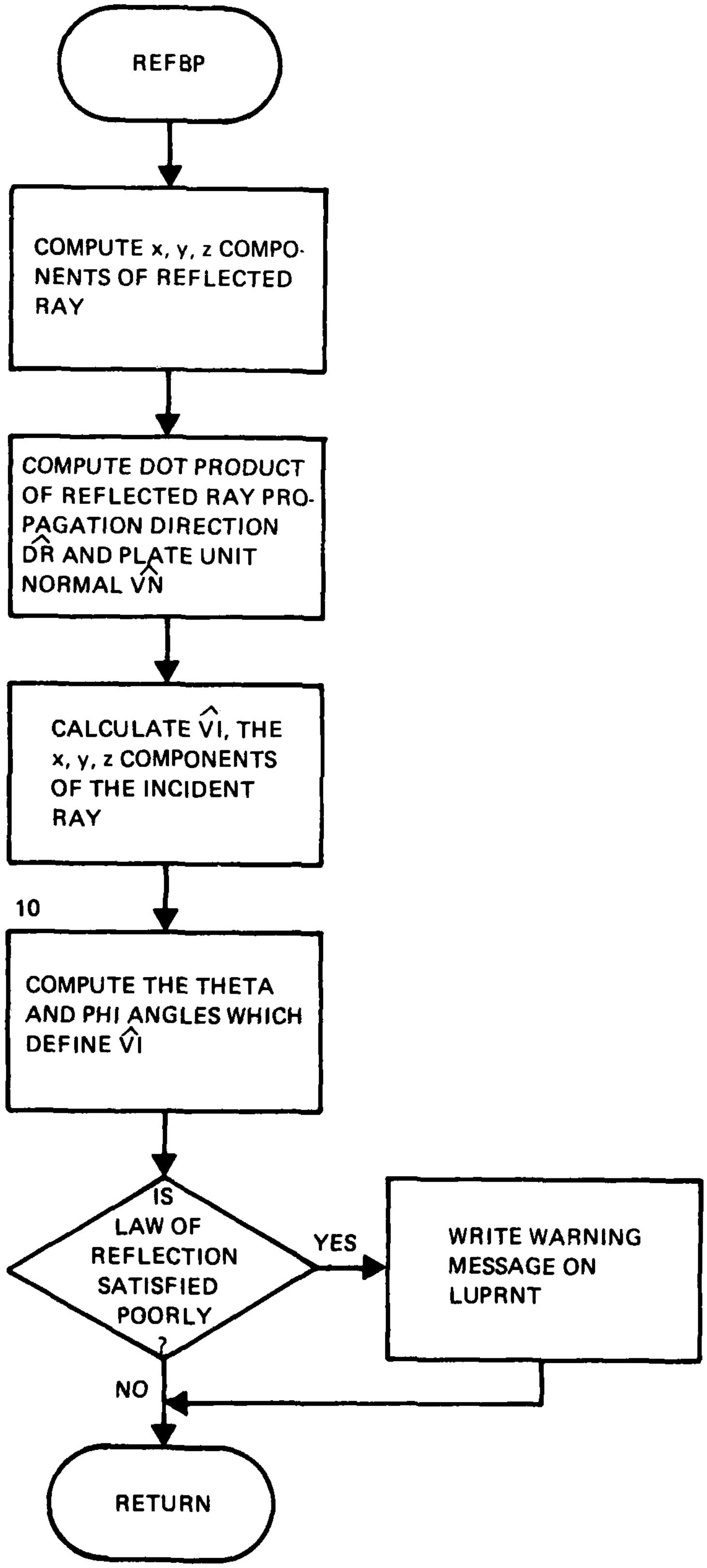
B. OUTPUT	LOCATION
PHIR	F.P.
THIR	F.P.

6. CALLING ROUTINES:

DPLRPL	RPLRCL
RCLRPL	RPLRPL
REFPLA	RPLSCL
RPLDPL	SCLRPL

7. CALLED ROUTINE:

BTAN2


REFBP
COMPUTE x, y, z COMPONENTS OF REFLECTED RAY
COMPUTE DOT PRODUCT OF REFLECTED RAY PROPAGATION DIRECTION $\hat{DR}$ AND PLATE UNIT NORMAL $\hat{VN}$
CALCULATE $\hat{VI}$, THE x, y, z COMPONENTS OF THE INCIDENT RAY
10
COMPUTE THE THETA AND PHI ANGLES WHICH DEFINE $\hat{VI}$
IS LAW OF REFLECTION SATISFIED POORLY ?
YES
WRITE WARNING MESSAGE ON LUPRNT
NO
RETURN

1. NAME: REFCAP (GTD)

2. PURPOSE: To calculate the unobstructed electric field resulting from the reflection of a unit source off a given cylinder end cap.

3. METHOD: REFCAP is the driver routine which directs all the ray tracing, physics and field calculations for determining the electric field reflected by an elliptical cylinder end cap in a given far-field direction or to a given near-field observation point from a unit source. The important geometry is shown in figure 1.

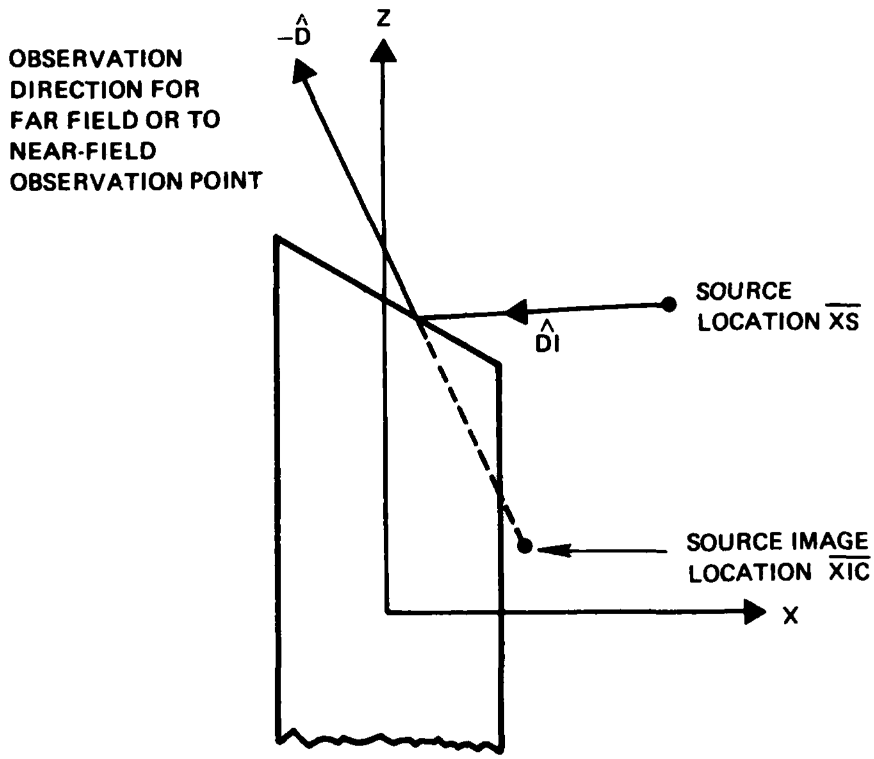


Figure 1. Illustration of Source Ray Reflection from End Cap

First, the ray from the source image location is checked to make sure it passes through the given cylinder end cap. If it does not, the theta and phi components of the field are set to zero, and no other computations except debug functions (if requested) are performed in this routine. If reflection can occur, the ray path from the reflection point in the far-field observation direction or to the near-field observation point is checked for obstructions. If it is blocked by a plate, the field components are set to zero, and no other computations except debug functions (if requested) are

performed in this routine. If the path is unobstructed, the ray path from the source location to the reflection point is checked for obstructions. If a plate blocks this path, the theta and phi field components are set to zero, and no other computations except debug functions (if requested) are performed in this routine. If this path is clear, it is then known that reflection off the given end cap did occur and that the complete ray path is unobstructed.

The source field pattern factor from the source image location is computed by calling subroutine SOURCE and multiplying the returned field values by the reflection coefficient. Then the phase factor is computed. For far field this factor refers the field to the reference coordinate system (RCS) origin. For near field, the phase factor includes the spherical wave spread factor. Now the theta and phi components of the field can be computed. The electric field is given by:

$$\bar{E} = (\underbrace{EF\ \hat{\theta}}_{\text{theta component of source factor}} + \underbrace{EG\ \hat{\phi}}_{\text{phi component of source factor}})\ \underbrace{e^{j2\pi(\overline{XIC}\cdot\hat{D})}}_{\text{EX - phase factor}}, \text{ for far field}$$

and

$$\bar{E} = (\underbrace{EF\ \hat{\theta}}_{\text{theta component of source factor}} + \underbrace{EG\ \hat{\phi}}_{\text{phi component of source factor}})\ \underbrace{\frac{e^{-j2\pi SNF}}{SNF}}_{\text{EX - phase factor}}, \text{ for near field.}$$

where $SNF = |\overline{FLDPT} - \overline{XIC}$

The x, y, z components of the field are then computed and added to the previous components due to other reflection-diffraction interactions. The values are stored in common block /FLDXYZ/.

If the debug capabilities have been requested, the end cap reflected field magnitude is computed. The magnitude, theta and phi complex components are printed on file LUPRNT.

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
D	Observation direction unit vector
DHIT	Distance from source to hit point on plate (from PLAINT)
DHT	Distance from source to hit point on end cap (from CAPINT)
DI	Unit vector of incident ray propagation direction
DN	Dot product of reflected ray propagation direction and end cap unit normal
DNI	Dot product of incident ray and end cap unit normal
EF	Pattern factor for theta component of incident E-field
EG	Pattern factor for phi component of incident E-field
EIX	X component of source pattern factor of incident E-field
EIY	Y component of source pattern factor of incident E-field
EIZ	Z component of source pattern factor of incident E-field
EPH	Phi component of reflected E-field in RCS
ETH	Theta component of reflected E-field in RCS
EX	Phase term and for near field it also contains the spherical wave spread factor
FLDMAG	The electric field magnitude
FLDPT	The near-field observation point in x,y,z components
GAM	Phase term parameter

LHIT	Set true if ray hits plate (from PLAINT)
MC	End cap where reflection occurs
N	DO loop variable
NC	Sign change variable
NI	DO loop variable
NJ	DO loop variable
PHSR	Observation direction phi angle
SNF	Distance from field observation point to source image location
THSR	Observation direction theta angle
VAX	X,Y,Z components defining the image source coordinate system in x,y,z RCS components
VN	Unit normal to end cap in RCS x,y,z components
XIS	Source image location
XS	Source location in x,y,z components
XSS	Source location in x,y,z components in RCS

5. I/O VARIABLES:

A. INPUT

INPUT	LOCATION
CNC	/GEOMEL/
D	/DIR/
FLDPT	/NEAR/
LDEBUG	/TEST/
LNRFLD	/NEAR/
LUPRNT	/ADEBUG/
MC	F.P.

PHSR	/DIR/
SNC	/GEOMEL/
THSR	/DIR/
TPI	/PIS/
VXIC	/IMCINF/
XIC	/IMCINF/
XS	/SORINF/

B.

OUTPUT	LOCATION
EPH	F.P.
ETH	F.P.

6. CALLING ROUTINE:

GTDDRV

7. CALLED ROUTINES:

ASSIGN

BEXP

CAPINT

NFD

PLAINT

SMAGNF

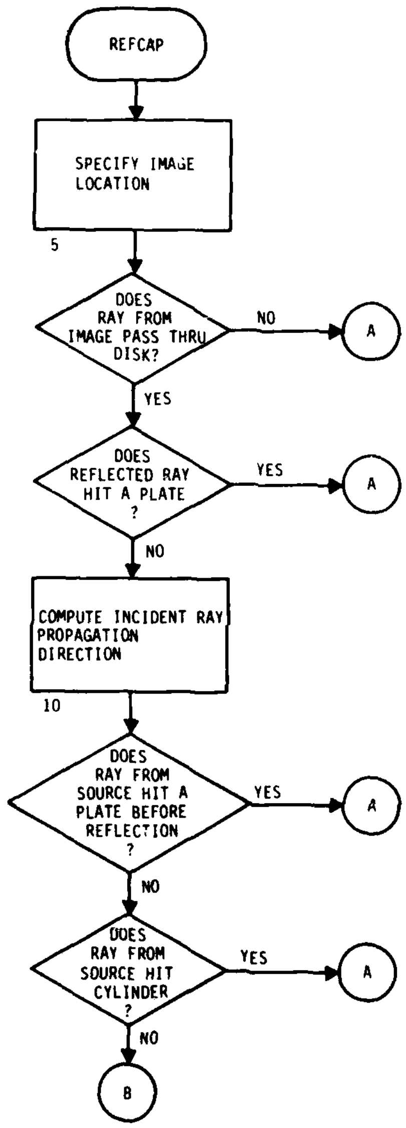
SOURCE

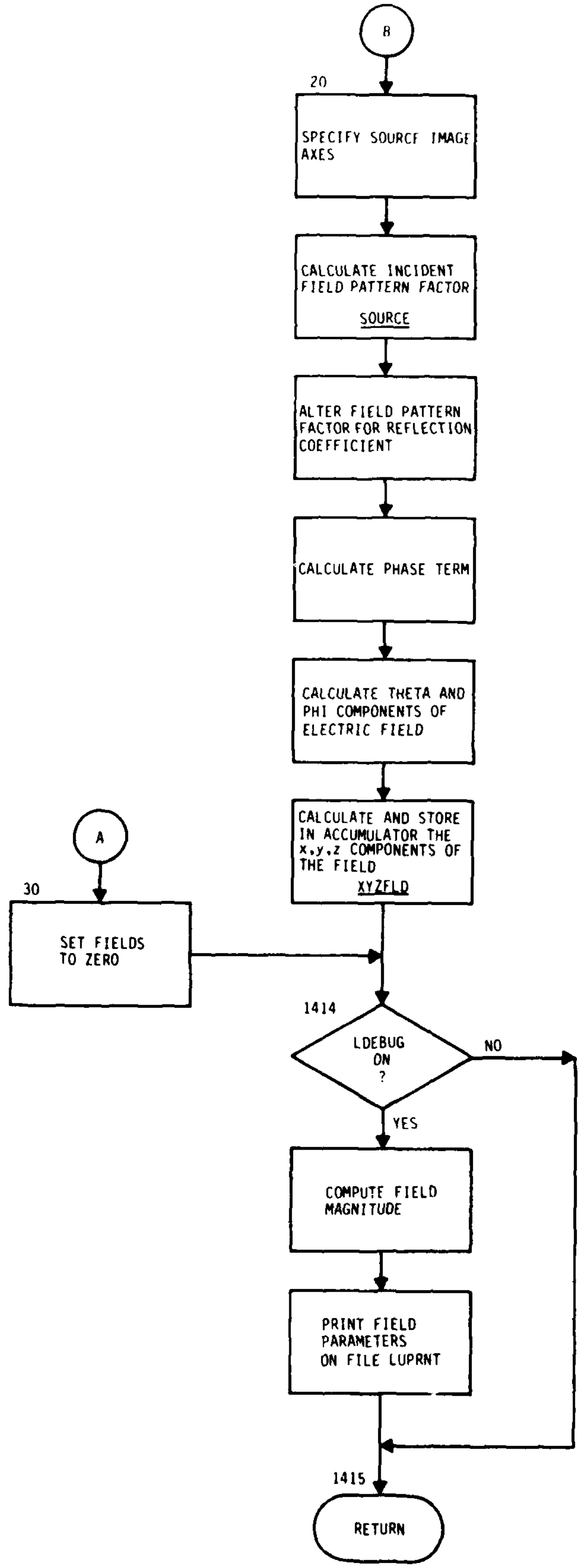
STATIN

STATOT

WLKBCK

XYZFLD


REFCAP
SPECIFY IMAGE LOCATION
5
DOES RAY FROM IMAGE PASS THRU DISK?
NO
A
YES
DOES REFLECTED RAY HIT A PLATE ?
YES
A
NO
COMPUTE INCIDENT RAY PROPAGATION DIRECTION
10
DOES RAY FROM SOURCE HIT A PLATE BEFORE REFLECTION ?
YES
A
NO
DOES RAY FROM SOURCE HIT CYLINDER ?
YES
A
NO
B


B
20
SPECIFY SOURCE IMAGE AXES
CALCULATE INCIDENT FIELD PATTERN FACTOR
SOURCE
ALTER FIELD PATTERN FACTOR FOR REFLECTION COEFFICIENT
CALCULATE PHASE TERM
CALCULATE THETA AND PHI COMPONENTS OF ELECTRIC FIELD
CALCULATE AND STORE IN ACCUMULATOR THE x,y,z COMPONENTS OF THE FIELD
XYZFLD
A
30
SET FIELDS TO ZERO
1414
LDEBUG ON ?
NO
YES
COMPUTE FIELD MAGNITUDE
PRINT FIELD PARAMETERS ON FILE LUPRNT
1415
RETURN

1. NAME: REFCYL (GTD)

2. PURPOSE: *To compute the geometrical optics field due to reflection of a unit source off the curved surface of the elliptical cylinder.*

3. METHOD: REFCYL functions as a service routine for subroutine SCTCYL, where the total cylinder-scattered field is computed. The field components computed in REFCYL which are used in SCTCYL are the hard (EHTH, EHPH) and soft (ESTH, ESPH) theta and phi components of the field incident on the cylinder at the cylinder reflection point. These components along with several other useful parameters are passed to subroutine SCTCYL through common block /FUDG/. The geometrical optics reflected field components ETH and EPH are computed in REFCYL. These are calculated for the cylinder-reflected field from a unit source in a given far-field observation direction or to a given near-field observation point. These components are not used presently. Pertinent geometry is shown in figure 1.

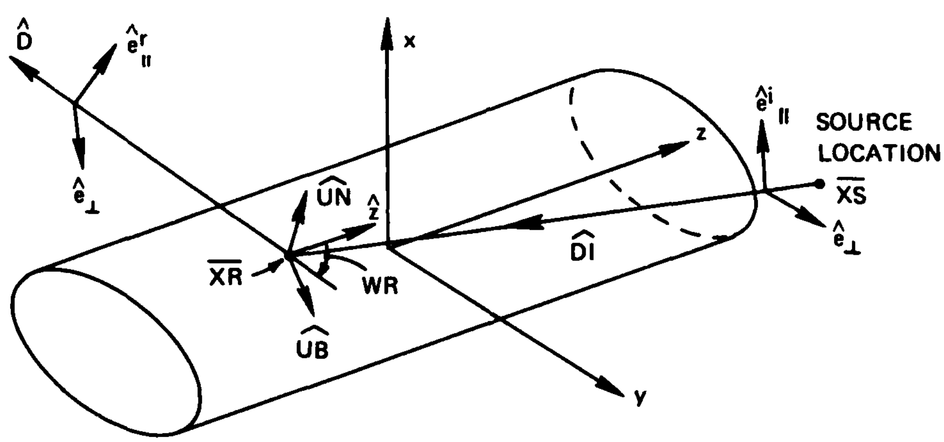


Figure 1. Geometry of Ray Reflected From Cylinder

The code first checks to see if reflection is possible. If it is not possible the code sets flags to indicate that starting point data are not available for the next time REFCYL is called and that reflection did not occur. The fields are set to zero and control is returned to the calling routine. If reflection is possible, the reflection point is computed by calling subroutine RFDFIN for near-field calculations and by calling subroutine RFPTCL for far-field calculations. Then the far-field reflection point is checked to make sure it satisfies the law of reflection. This is based on a returned value from RFPTCL. Then for both far-field and near-field cases, the reflection point is checked to make sure it lies on the

PREVIOUS PAGE IS BLANK

curved sides of the cylinder within the end cap boundaries. Next the ray path is checked to make sure it is not shadowed. If it is shadowed, the code sets the flag which indicates a reflected field did not occur and sets the field to zero. Control is then returned to the calling routine. If the ray path is unobstructed, then at this point it is known that reflection did occur and the fields can be computed.

The physics and field calculations begin by computing the source field pattern factor from the source and computing the cylinder-reflected wave spreading radii. Other parameters and polarization vectors are then calculated for the field computations. (See the flowchart). The code computes the field incident on the cylinder and the field reflected from the cylinder. The phase factor refers the far-field cylinder-reflected field to the origin of the reference coordinate system (RCS), and includes for near-field calculations the spherical wave spreading factor. The code ends by computing the hard (theta and phi) and soft (theta and phi) components of the field incident on the cylinder at the reflection point.

Additional, in-depth details to this solution are given on pages 105-107 of reference A.

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
CSV	Cosine of VR
CTHI	Dot product of cylinder normal and reflection propagation direction unit vector
CW	Cosine of WR
D	Propagation direction after reflection in x,y,z RCS components
D1	Variable used in various near-field calculations as a unit vector to indicate the direction between two points
D2	Variable used in various near-field calculations as a unit vector to indicate the direction between two points
D12	Dot product of source vectors tangent to cylinder (2-D)

DD	Normalization constant for reflection point unit normal (from RFPTCL)
DD1	Dot product of unit vector of propagation direction and cylinder tangent unit vector through tangent point 1 (2-D)
DD2	Dot product of unit vector of propagation direction and cylinder tangent unit vector through tangent point 2 (2-D)
DHIT	Distance from source to hit point (from PLAINT)
DICOEF	X,Y, and Z components of incident ray direction in RCS
DOTP	Difference of dot products returned from subroutine RFPTCL (2-D)
DP	The phi unit vector for observation direction D
DT	The theta unit vector for observation direction D
DXY	Dot product of vector from origin to source and propagation direction (2-D)
EF	Pattern factor of theta component of incident field in RCS
EG	Pattern factor of phi component of incident field in RCS
EHPH	Phi component of the hard component of field incident on cylinder
EHTH	Theta component of the hard component of field incident on cylinder
EIPP	Incident field component parallel to plane of incidence
EIPR	Incident field component perpendicular to plane of incidence
EPH	Phi component of reflected E-field

ERPP	Reflected field component parallel to plane of incidence
ERPR	Reflected field component perpendicular to plane of incidence
ERX,ERY,ERZ	X,Y,Z components of reflected field in RCS (Also used to define components incident on cylinder)
ESPH	Phi component of the soft component of field incident on cylinder
ESTH	Theta component of the soft component of field incident on cylinder
ETH	Theta component of reflected E-field
EX,EY,EZ	Pattern factor of x,y,z components of incident field in RCS
FPTXY	The equivalent near-field observation point in the x-y plane
LHIT	Set true if ray hits plate (from PLAINT)
LRFC	Set true if reflection data are available from previous pattern angle (or for next pattern angle when leaving routine)
LTRF	Set true if geometrical optics reflected field does not exist
ORIGIN	The x,y,z components of the origin of the reference coordinate system (0., 0., 0.)
PH	Phase and magnitude constant for incident or reflected field
PHIR	Phi component of incident ray direction
PHSR1	Variable used in various near-field calculations to indicate the phi angle between two points
PHSR2	Variable used in various near-field calculations to indicate the phi angle between two points

RG	Parameter used in transition function
RHO1	Ray spreading radius in plane of cylinder curvature at reflection point
RHO2	Ray spreading radius in plane normal to plane of incidence at reflection point
S	Distance from source to reflection point in x-y plane
SMAG	Distance from source to reflection point
SNF	Distance between near-field observation point and the reflection point
SNV	Sine of VR
SNX	X component of normal at cylinder reflection point
SNY	Y component of normal at cylinder reflection point
SQRH	Spreading factor
SW	Sine of WR
SXN,SYN,SZN	X, Y, and Z components of unit vector of ray from reflection point to source in RCS
THIR	Theta component of incident ray direction
THSR1	Variable used in various near-field calculations to indicate the theta angle between two points
THSR2	Variable used in various near-field calculations to indicate the theta angle between two points
TRAN	Parameter used in transition function
TX1	X component of source vector tangent to tangent point 1 (2-D)
TX2	X component of source vector tangent to tangent point 2 (2-D)

TY1	Y component of source vector tangent to tangent point 1 (2-D)
TY2	Y component of source vector tangent to tangent point 2 (2-D)
UB	X,Y components of unit vector tangent to cylinder reflection point in RCS (2-D)
UIPPX,UIPPY,UIPPZ	X,Y,Z components of incident field polarization unit vector parallel to plane of incidence
UIPRX,UIPRY,UIPRZ	X,Y,Z components of incident/reflected field polarization unit vector perpendicular to plane of incidence
UN	X,Y components of unit normal to cylinder reflection point in RCS (2-D)
URPPX,URPPY,URPPZ	X,Y,Z components of reflected field polarization unit vector parallel to plane of incidence
VR	Elliptical angle defining reflection point in RCS x-y plane
VXS	X,Y,Z components of unit vectors defining source coordinate system axes in RCS
WR	Phi angle defining propagation direction in cylinder reflection point coordinate system
XE1	Point which lies on the infinite cylinder whose z component is equal to the intersection point on the z axis with the more positive end cap and whose x and y values are based on the elliptical cylinder's radii at the phi angle of a vector from the RCS origin to the field point
XE2	Point which lies on the infinite cylinder whose z component is equal to the intersection point on the z axis with the more negative end cap and whose x and y values are based on the elliptical cylinder's radii at the phi angle of a vector from the RCS origin to the field point

XR	Location of reflection point in x, y, z reference coordinate system (RCS) coordinates
XSS	Source location in x,y,z components
XT1	The x,y,z components of tangent point 1 (2-D)
XT2	The x,y,z components of tangent point 2 (2-D)

5. I/O VARIABLES:

A. INPUT

INPUT	LOCATION
A	/GEOMEL/
B	/GEOMEL/
BTS	/BNDSCL/
CPS	/DIR/
CTC	/GEOMEL/
CTHS	/DIR/
D	/DIR/
DP	/THPHUV/
DT	/THPHUV/
DTS	/BNDSCL/
FLDPT	/NEAR/
LNRFLD	/NEAR/
LRFC	/CLRFC/
PHSR	/DIR/
PI	/PIS/
SPS	/DIR/
STHS	/DIR/

THSR	/DIR/
TPI	/PIS/
VTS	/BNDSCL/
VXS	/SORINF/
XS	/SORINF/
ZC	/GEOMEL/

B. OUTPUT LOCATION

EHPH	/FUDG/
EHTH	/FUDG/
EPH	F.P.
ESPH	/FUDG/
ESTH	/FUDG/
ETH	F.P.
LTRF	/FUDG/
RG	/FUDG/
RHO1	/FUDG/
SMAG	/FUDG/
TRAN	/FUDG/
XR	/FUDG/

6. CALLING ROUTINE:

SCTCYL

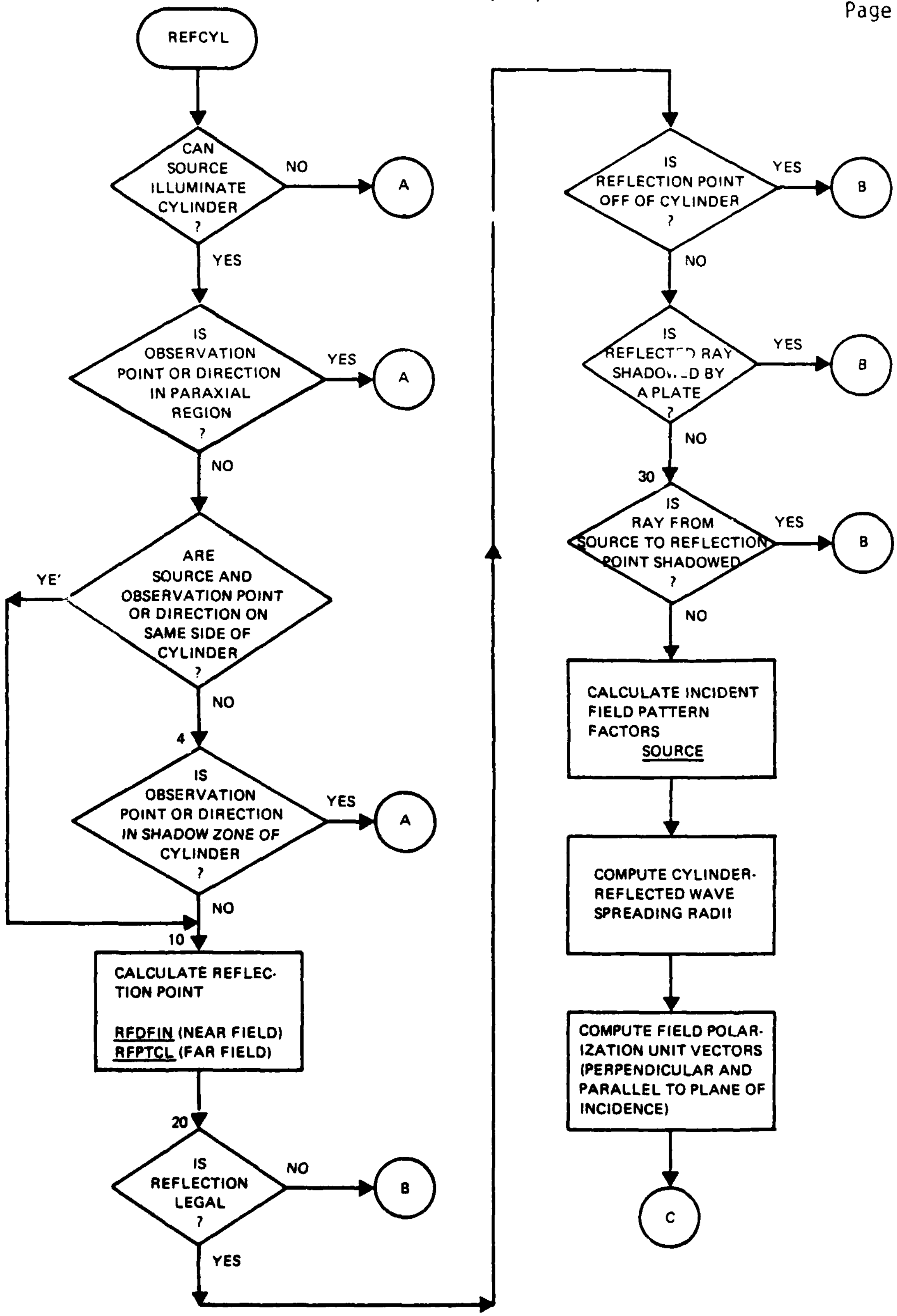
7. CALLED ROUTINES:

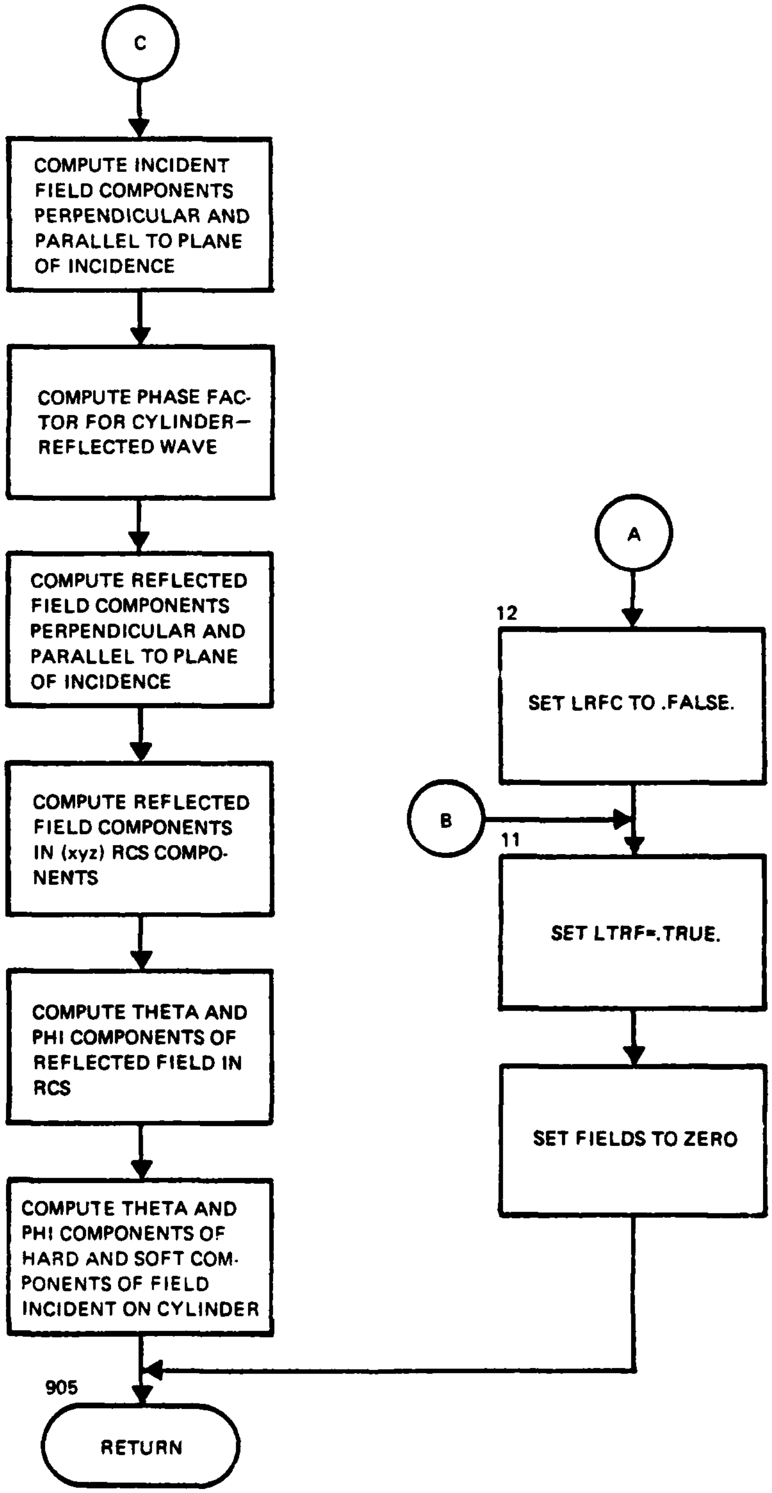
ASSIGN	RFPTCL
BEXP	SMAGNF
BTAN2	SOURCE

NANDB	STATIN
NDF	STATOT
PLAINT	TPNFLD
RFDFIN	WLKBCK

8. REFERENCE:

A. R. J. Marhefka, "Analysis of Aircraft Wing-Mounted Antenna Patterns," Report 2902-25, June 1976, The Ohio State University ElectroScience Laboratory, Department of Electrical Engineering; prepared under Grant No. NGL 36-008-138 for National Aeronautics and Space Administration.


REFCYL
CAN SOURCE ILLUMINATE CYLINDER ?
NO
A
YES
IS OBSERVATION POINT OR DIRECTION IN PARAXIAL REGION ?
YES
A
NO
ARE SOURCE AND OBSERVATION POINT OR DIRECTION ON SAME SIDE OF CYLINDER ?
YE'
NO
4
IS OBSERVATION POINT OR DIRECTION IN SHADOW ZONE OF CYLINDER ?
YES
A
NO
10
CALCULATE REFLECTION POINT
RFDFIN (NEAR FIELD)
RFPTCL (FAR FIELD)
20
IS REFLECTION LEGAL ?
NO
B
YES
IS REFLECTION POINT OFF OF CYLINDER ?
YES
B
NO
IS REFLECT?D RAY SHADO??D BY A PLATE ?
YES
B
NO
30
IS RAY FROM SOURCE TO REFLECTION POINT SHADOWED ?
YES
B
NO
CALCULATE INCIDENT FIELD PATTERN FACTORS
SOURCE
COMPUTE CYLINDER-REFLECTED WAVE SPREADING RADII
COMPUTE FIELD POLARIZATION UNIT VECTORS (PERPENDICULAR AND PARALLEL TO PLANE OF INCIDENCE)
C


C
COMPUTE INCIDENT FIELD COMPONENTS PERPENDICULAR AND PARALLEL TO PLANE OF INCIDENCE
COMPUTE PHASE FACTOR FOR CYLINDER—REFLECTED WAVE
COMPUTE REFLECTED FIELD COMPONENTS PERPENDICULAR AND PARALLEL TO PLANE OF INCIDENCE
COMPUTE REFLECTED FIELD COMPONENTS IN (xyz) RCS COMPONENTS
COMPUTE THETA AND PHI COMPONENTS OF REFLECTED FIELD IN RCS
COMPUTE THETA AND PHI COMPONENTS OF HARD AND SOFT COMPONENTS OF FIELD INCIDENT ON CYLINDER
905
RETURN
A
12
SET LRFC TO .FALSE.
B
11
SET LTRF=.TRUE.
SET FIELDS TO ZERO

1. NAME: REFLCT (INPUT)

2. PURPOSE: To execute a coordinate reflection for the geometry processor.

3. METHOD: The axis along which the reflection is to take place is determined, that coordinate sign is changed, and control is returned to the calling subroutine.

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
IRF	Input argument determining axis of reflection: IRF=1 for X axis, =2 for Y axis, =3 for Z axis
JAXIS	Variable IRF minus 2 for arithmetic IF statement

5. I/O VARIABLES:

A. INPUT

INPUT	LOCATION
IRF	F.P.
X	F.P.
Y	F.P.
Z	F.P.

B. OUTPUT

OUTPUT	LOCATION
X	F.P.
Y	F.P.
Z	F.P.

6. CALLING ROUTINES:

WYRDRV

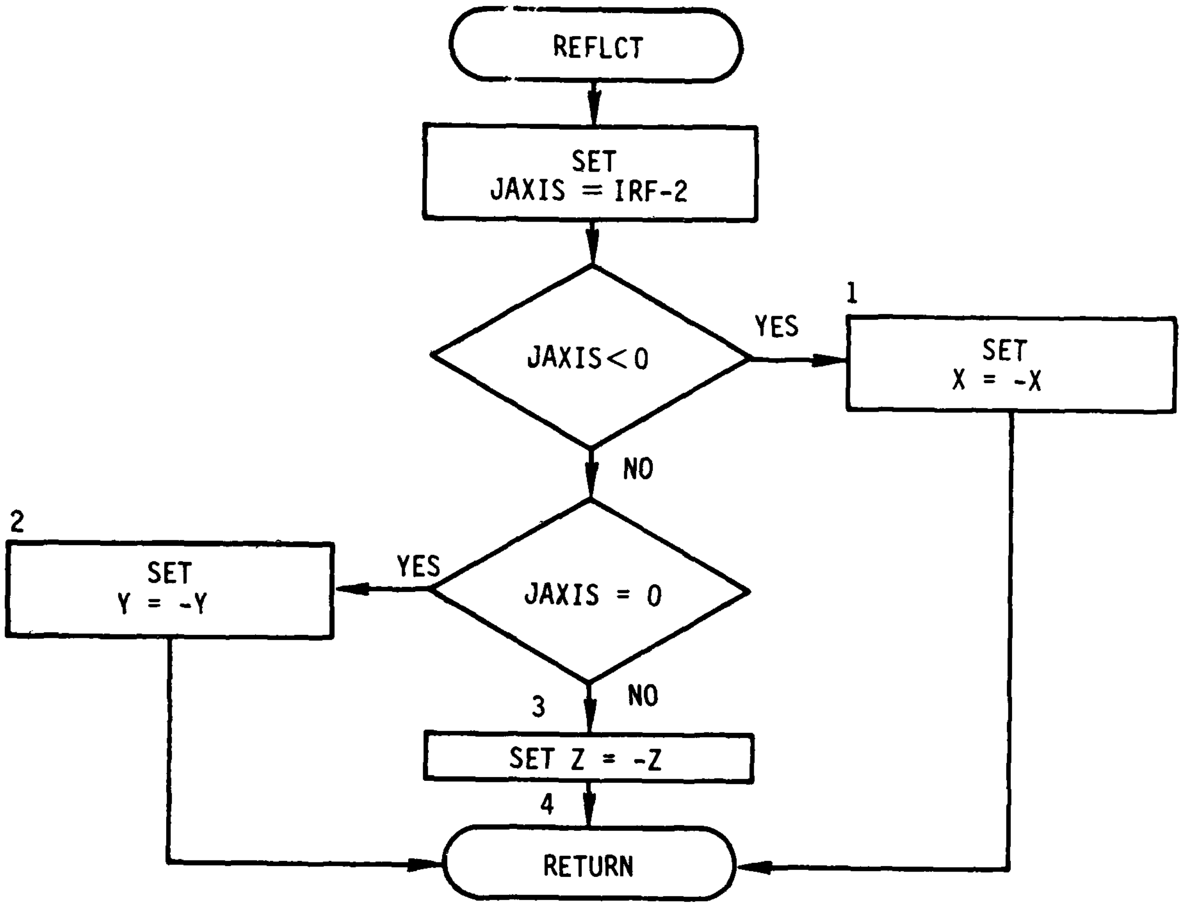
SPWDRV

7. CALLED ROUTINES:

NONE

PREVIOUS PAGE IS BLANK

REFLCT (INPUT)



1. NAME: REFPLA (GTD)

2. PURPOSE: To calculate the unobstructed electric field due to single reflection from a given plate from a unit source.

3. METHOD: REFPLA is the driver routine which directs all the ray tracing, physics and field calculations for determining the electric field resulting from single reflection off a given plate in a given far-field direction or to a given near-field point from a unit source. The significant geometry is shown in figure 1.

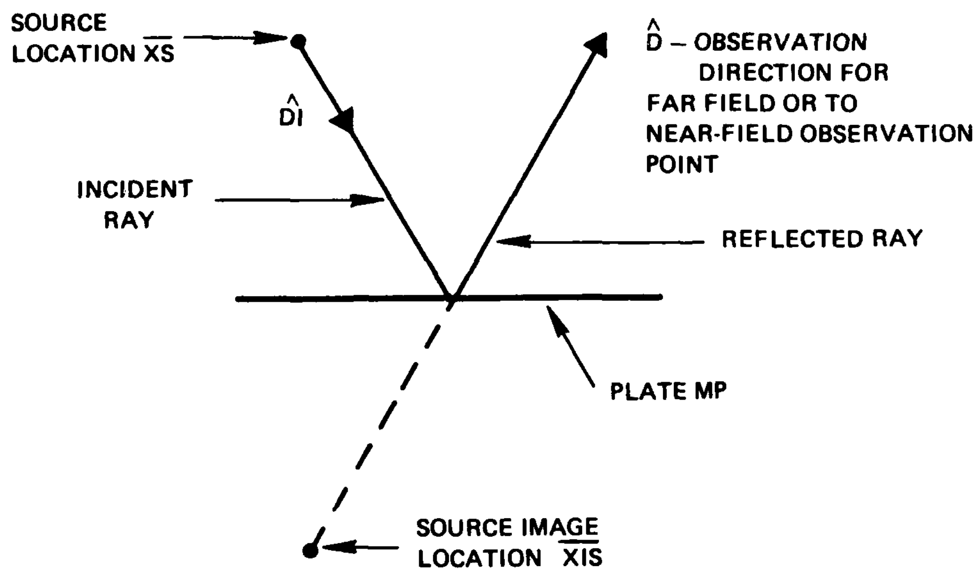


Figure 1. Geometry for Source Ray Reflection from Plate

First the ray path from the source image location in the desired direction is checked to make sure it does pass through the plate being considered. If it does not, the theta and phi components of the electric field are set to zero, and no other calculations except for debug functions (if requested) are performed in this routine. If reflection can occur, the ray path from the reflection point on the plate in the given far-field observation direction or to the given near-field observation field point is checked for obstructions. If the path is obstructed, the fields are set to zero, and no other calculations except for debug functions (if requested) are performed in this routine. If the path is clear, then the ray path from the source to the reflection point is checked. If this path is

blocked by another plate or a cylinder, the fields are set to zero, and no other calculations except for debug functions (if requested) are performed. If this path is clear, reflection from the given plate did occur and the complete ray path is unobstructed.

The source field pattern factor from the source image location is computed by calling subroutine SOURCE and multiplying the returned values by the reflection coefficient. Next the phase factor is computed. For far field, this will refer the field back to the origin of the reference coordinate system. For near field, the phase factor includes the spherical wave spread factor. Now the theta and phi components of the electric field are computed. The electric field in theta and phi components is given by:

$$\bar{E} = (\underbrace{EF\ \hat{\theta}}_{\text{theta component of source factor}} + \underbrace{EG\ \hat{\phi}}_{\text{phi component of source factor}})\ \underbrace{e^{j2\pi(\overline{XIS} \cdot \hat{D})}}_{\text{EX - phase factor}}, \text{ for far field}$$

and

$$\bar{E} = (\underbrace{EF\ \hat{\theta}}_{\text{theta component of source factor}} + \underbrace{EG\ \hat{\phi}}_{\text{phi component of source factor}})\ \underbrace{\frac{e^{-j2\pi SNF}}{SNF}}_{\text{EX - phase factor}}, \text{ for near field.}$$

where $SNF = |\overline{FLDPT} - \overline{XIS}|$

The x,y,z components of the electric field are computed and added to the previous components due to other reflection-diffraction interactions. The values are stored in the /FLDXYZ/ common block.

If the debug capabilities have been requested, the field magnitude is computed. The magnitude, theta and phi components are printed on file LUPRNT.

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
CPHI	Cosine of PHIR

CTHI	Cosine of THIR
D	Unit vector x,y,z components of ray propagation direction after reflection in RCS
DHIT	Distance from source to reflection point (from PLAINT)
DHT	Distance from source to hit point (from PLAINT and CYLINT)
DICOEF	Unit vector x,y,z components of incident ray propagation direction in RCS
EF	Pattern factor for theta component of source field in RCS
EG	Pattern factor for phi component of source field in RCS
EIX	X component of source factor
EIY	Y component of source factor
EIZ	Z component of source factor
ERP	Phi component of reflected field in RCS
ERT	Theta component of reflected field in RCS
EX	Complex phase factor
FLDMAG	The electric field magnitude
FLDPT	The x,y,z components of the field point location
FX,FY,FZ	The x,y,z components of the accumulated electric field from all geometry interactions
GAM	Phase distance to origin (dot product of image location and reflected ray propagation direction)
LDEBUG	Logical variable set true if debug requested

LHIT	Set true if ray intersects a plate or cylinder (from PLAINT or CYLINT)
LNRFLD	Flag to indicate if near-field (LNRFLD=1) or far-field (LNRFLD=0) calculations were requested
LUPRNT	Output file number
MP	Plate from which reflection occurs
N	DO loop variable
NI	DO loop variable
NJ	DO loop variable
PHIR	Phi component of incident ray propagation direction in RCS
PHSR	Phi component of ray propagation direction after reflection in RCS
SNF	Distance between source image and field point
SPHI	Sine of PHIR
STHI	Sine of THIR
THIR	Theta component of incident ray propagation direction in RCS
THSR	Theta component of ray propagation direction after reflection in RCS
TPI	2π
VAX	X,Y,Z components defining unit vectors of the source image coordinate system axes in RCS
VXI	Array of components defining unit vectors of the source image coordinate system axes in RCS
XI	Triply dimensioned array of image locations

XIS	X,Y,Z components of source image location (single reflection from plate MP)
XQS	X,Y,Z components of source image location
XS	Source location in x,y,z RCS

5. I/O VARIABLES:

A. INPUT

INPUT	LOCATION
D	/DIR/
FLDPT	/NEAR/
FX	/FLDXYZ/
FY	/FLDXYZ/
FZ	/FLDXYZ/
LDEBUG	/TEST/
LNRFLD	/NEAR/
LUPRNT	/ADEBUG/
MP	F.P.
PHSR	/DIR/
THSR	/DIR/
TPI	/PIS/
VXI	/IMAINF/
XI	/IMAINF/
XS	/SORINF/

B. OUTPUT

OUTPUT	LOCATION
ERP	F.P.
ERT	F.P.
FX	/FLDXYZ/

FY	/FLDXYZ/
FZ	/FLDXYZ/

6. CALLING ROUTINE:

   GTDDRV

7. CALLED ROUTINES:

   ASSIGN

   BEXP

   CYLINT

   NFD

   PLAINT

   REFBP

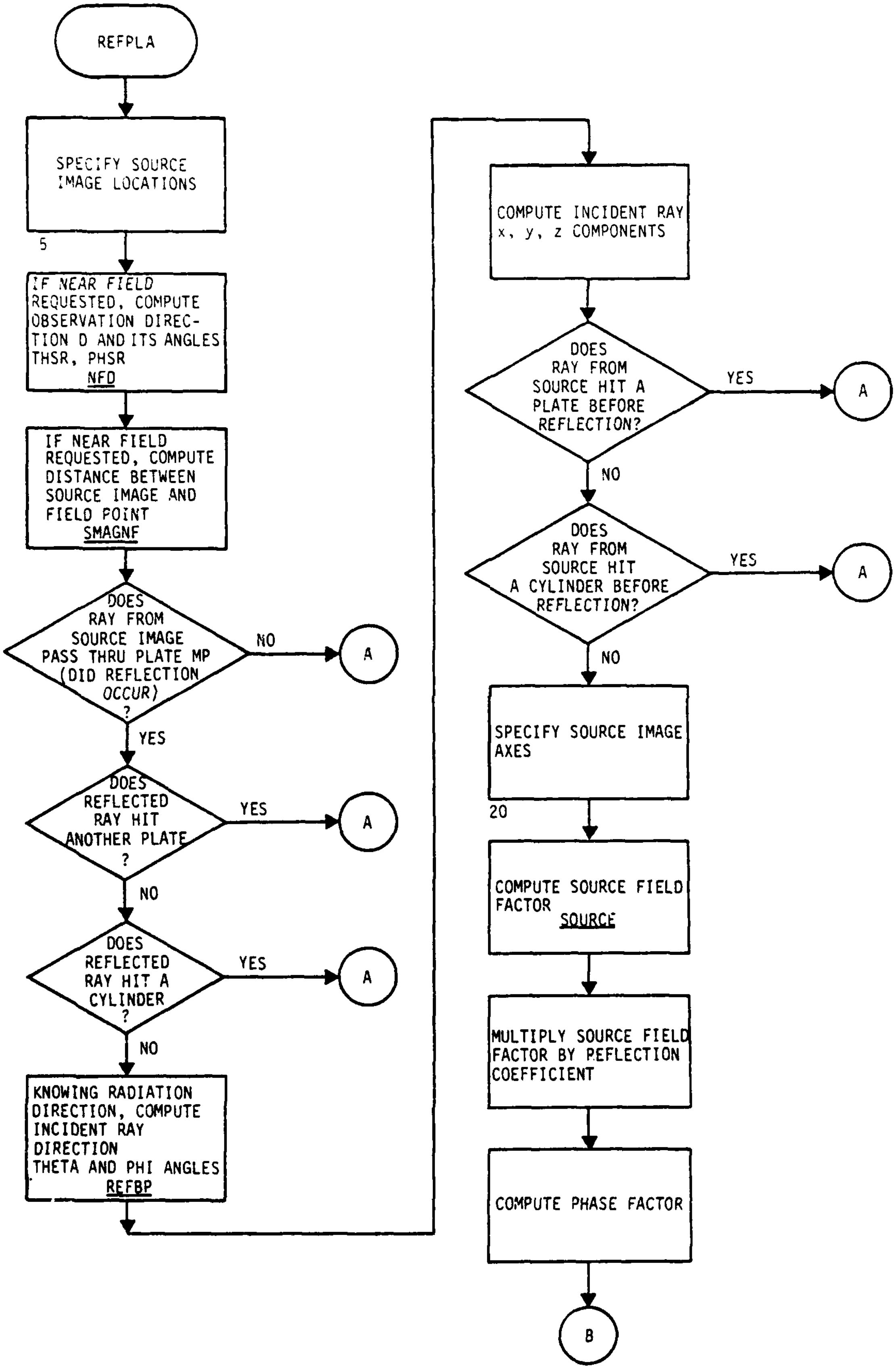
   SMAGNF

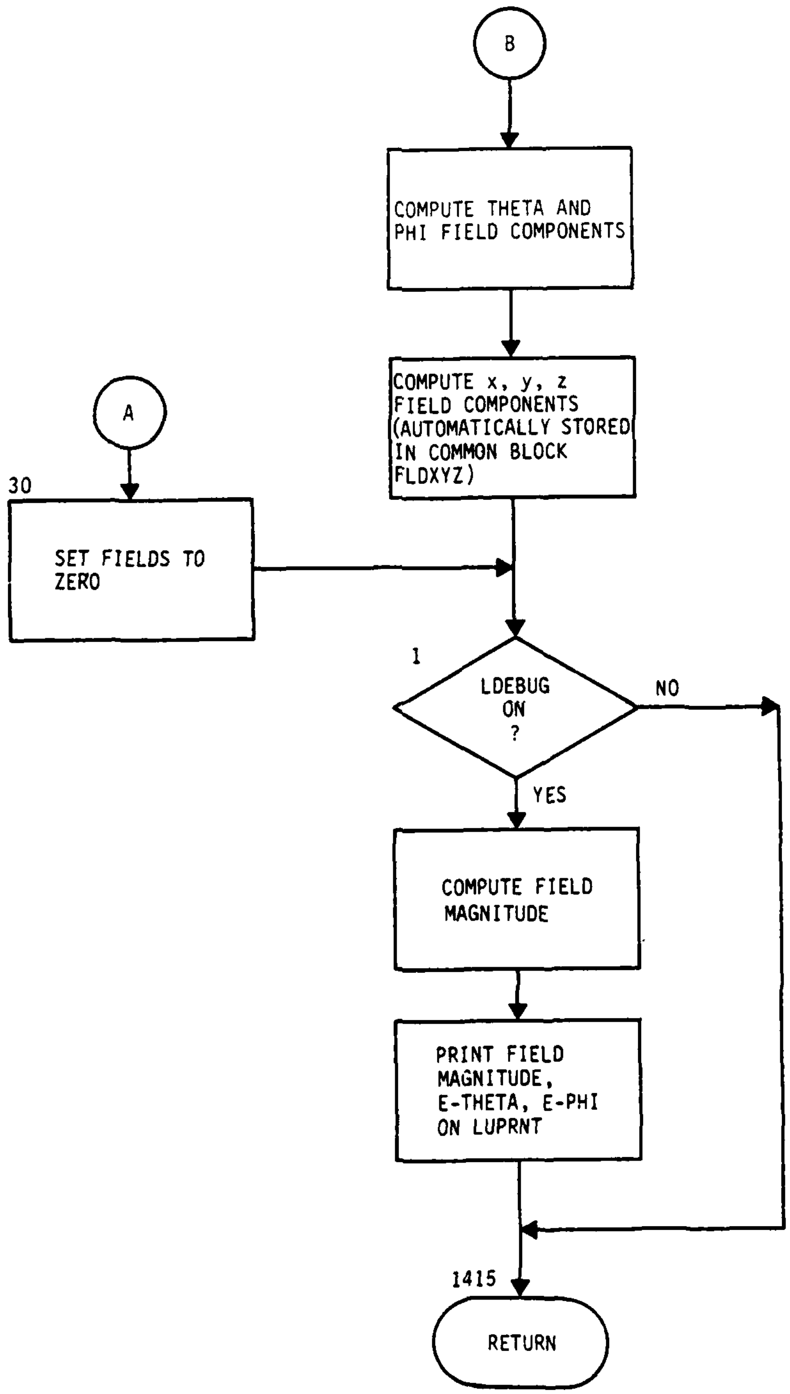
   SOURCE

   STATIN

   STATOT

   WLKBCK


REFPLA
SPECIFY SOURCE IMAGE LOCATIONS
5
IF NEAR FIELD REQUESTED, COMPUTE OBSERVATION DIRECTION D AND ITS ANGLES THSR, PHSR NFD
IF NEAR FIELD REQUESTED, COMPUTE DISTANCE BETWEEN SOURCE IMAGE AND FIELD POINT SMAGNF
DOES RAY FROM SOURCE IMAGE PASS THRU PLATE MP (DID REFLECTION OCCUR) ?
NO
A
YES
DOES REFLECTED RAY HIT ANOTHER PLATE ?
YES
A
NO
DOES REFLECTED RAY HIT A CYLINDER ?
YES
A
NO
KNOWING RADIATION DIRECTION, COMPUTE INCIDENT RAY DIRECTION THETA AND PHI ANGLES REFBP
COMPUTE INCIDENT RAY x, y, z COMPONENTS
DOES RAY FROM SOURCE HIT A PLATE BEFORE REFLECTION?
YES
A
NO
DOES RAY FROM SOURCE HIT A CYLINDER BEFORE REFLECTION?
YES
A
NO
SPECIFY SOURCE IMAGE AXES
20
COMPUTE SOURCE FIELD FACTOR SOURCE
MULTIPLY SOURCE FIELD FACTOR BY REFLECTION COEFFICIENT
COMPUTE PHASE FACTOR
B


B
COMPUTE THETA AND PHI FIELD COMPONENTS
COMPUTE x, y, z FIELD COMPONENTS (AUTOMATICALLY STORED IN COMMON BLOCK FLDXYZ)
A
30
SET FIELDS TO ZERO
1
LDEBUG ON ?
NO
YES
COMPUTE FIELD MAGNITUDE
PRINT FIELD MAGNITUDE, E-THETA, E-PHI ON LUPRNT
1415
RETURN

1. NAME: RESTRT (INPUT)

2. PURPOSE: Read common blocks and data sets from the checkpoint file.

3. METHOD: RESTRT searches for the desired checkpoint on the specified logical unit. The commons are read, the peripheral files are opened, and the data sets are restored. The search continues until the desired checkpoint has been read. If the desired checkpoint is not found, the routine writes an error message and terminates execution.

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
ICHKPT	The checkpoint number that will be used for restarting (default = 1)
ICKLOP	Loop index for reading commons and peripheral files
IEOF	Flag indicating that an end-of-file occurred while reading the checkpoint file
ISDBON	Flag for debug command
ISTRDT	Flag to tell when to store data on peripheral files
LOCTPO	Pointer for argument list
LUFILE	Checkpoint logical unit number specified by RSTART command
NAM	Temporary Hollerith location
NAMCPF	Name of module asked for by RESTRT command (default = INPUT)
NAME	File name or data set name
NDXNCD	Index of a keyword in the NCODES array
NREAD	Flag to tell RWCOMS to read common areas from IOCKPT
NUMCPF	Pointer to keyword of module for which RESTRT is requested

5. I/O VARIABLES:

A.

INPUT	LOCATION
IOCKPT	/SYSFIL/
ISOFF	/ADEBUG/
ISON	/ADEBUG/
KOLCOL	/PARTAB/
KOLNAM	/PARTAB/
KWCHKP	/PARTAB/
KWNAME	/PARTAB/
LUPRNT	/ADEBUG/
NAMSEG	/SEGMNT/
NARGTB	/PARTAB/
NCODES	/PARTAB/
NDATBL	/PARTAB/
NDEBUG	/SCNPAR/
NDXBLK	/SEGMNT/
NOPCOD	/ADEBUG/
NPDATA	/PARTAB/
NPTASK	/PARTAB/
NTSKTB	/PARTAB/
NUMCHK	/SYSFIL/
RSTART	/SYSFIL/
SEGTBL	/SEGMNT/

B. OUTPUT	LOCATION
CHKWRT	/SYSFIL/
DBGPRT	/ADEBUG/
IERRF	/ADEBUG/
IMDCHK	/ADEBUG/
INTARG	/ARGCOM/
IRSTRT	/ADEBUG/
LSTSYS	/SYSFIL/
LUDBUG	/ADEBUG/
NDEBUG	/SCNPAR/
NFINCD	/IOFLES/
NPTASK	/PARTAB/
NTSKTB	/PARTAB/
RSTART	/SYSFIL/
RSTRTA	/SYSFIL/

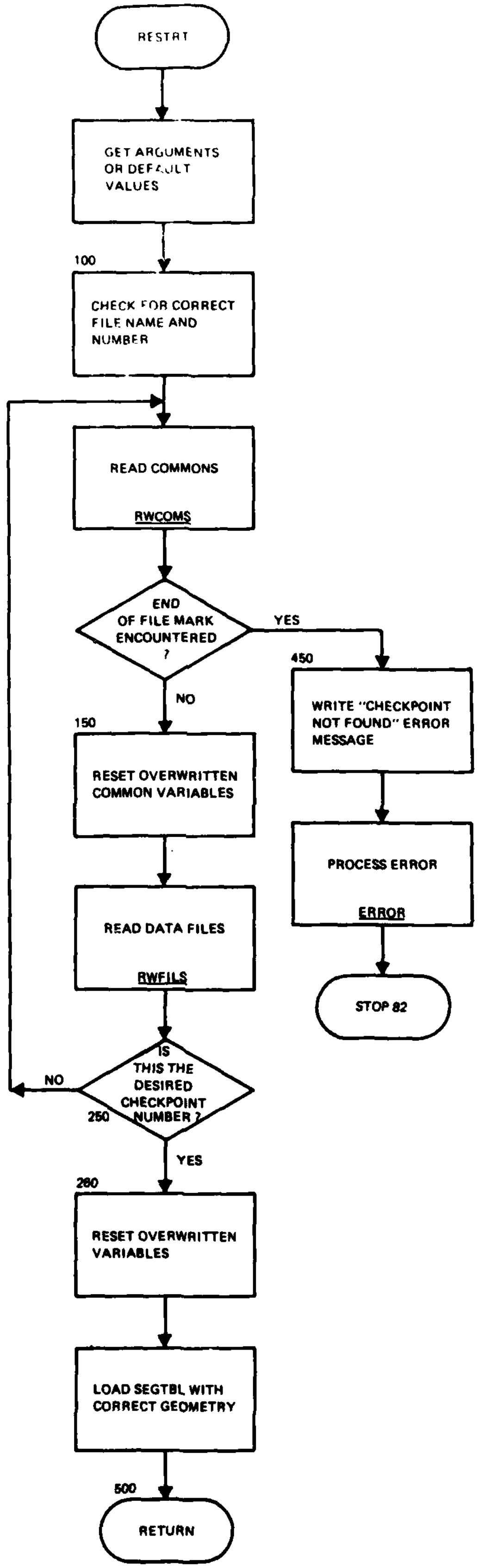
6. CALLING ROUTINE:

INPDRV

7. CALLED ROUTINES:

ASSIGN	RDEFIL
CONVRT	RWCOMS
ERROR	RWFILS
GETSYM	STATIN
POSTIP	STATOT
PUTSYM	WLKBCK

RESTRT (INPUT)



1. NAME: RFDFIN (GTD)

2. PURPOSE: To determine the reflection point on an elliptic cylinder for a given source and observation location in the near field of the cylinder.

3. METHOD: This subroutine solves a polynomial equation which is based on the geometry and satisfies Snell's law. The roots define possible reflection point locations. The true point is singled out using the laws of reflection. This procedure is explained in chapter IV of reference A. The coefficients are given on page 100 of the reference.

INTERNAL VARIABLES:

VARIABLE	DEFINITION
A	Cylinder radius along the x axis
B	Cylinder radius along the y axis
CA	Complex coefficients of sixth order polynomial equation
RT	Roots of polynomial equation
S	Smallest distance from source to reflection point to observation point
SM	Distance from source to reflection point plus the distance from the reflection point to the observation point
UR	Z component of reflection point on cylinder in RCS
VI	X,Y,Z components of reflected ray propagation direction
VIM	Normalization constant for VI
VM	Elliptical angle defining possible reflection point on cylinder
VR	Phi angle defining x and y components of reflection point
XC	X,Y,Z components of the observation point in the near field of the cylinder

XR	X,Y,Z components of reflection point location on cylinder
XS	Source location

5. I/O VARIABLES:

A. INPUT	LOCATION
A	/GEOMEL/
B	/GEOMEL/
XC	F.P.
XS	/SORINF/

B. OUTPUT	LOCATION
UR	F.P.
VI	F.P.
VR	F.P.

6. CALLING ROUTINES:

GEOMPC

RCLRPL

REFCYL

RPLRCL

7. CALLED ROUTINES:

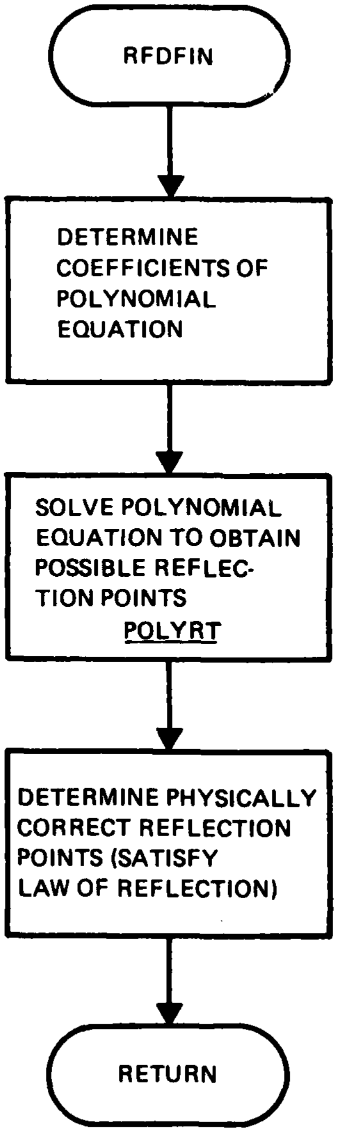
BTAN2

POLYRT

8. REFERENCE:

A. R. J. Marhefka, "Analysis of Aircraft Wing-Mounted Antenna Patterns," Report 2902-25, June 1976, the Ohio State University ElectroScience Laboratory, Department of Electrical Engineering; prepared under Grant No. NGL 36-008-138 for National Aeronautics and Space Administration.

RFDFIN (GTD)


RFDFIN
DETERMINE COEFFICIENTS OF POLYNOMIAL EQUATION
SOLVE POLYNOMIAL EQUATION TO OBTAIN POSSIBLE REFLEC-TION POINTS
POLYRT
DETERMINE PHYSICALLY CORRECT REFLECTION POINTS (SATISFY LAW OF REFLECTION)
RETURN

1. NAME: RFDFPT (GTD)

2. PURPOSE: To compute the ray path for a source ray which is reflected by the cylinder and then diffracted by a given edge on a given plate.

3. METHOD: The reflection point on an elliptic cylinder and the diffraction point on a plate edge for the reflected-diffracted ray in a given observation direction is calculated via an iterative process. The equations are based on a first order Taylor series approximation to the equations governing the laws of reflection and diffraction. The details of the analysis are given on pages 141-148 of reference A. The iteration process follows the same basic scheme outlined in the description for subroutines RFPTCL and DFRFPT. The initial start-up procedure for this subroutine is composed of locating the reflection point on the cylinder for a known diffraction point which is taken to be on the corners of the plate edge under consideration. The details of this procedure are discussed on pages 149-154 of reference A. Pertinent geometry is shown in figure 1. To avoid the 2π-to-0 transition in ϕ (a numerical jump in the variable representing the angle), the reference ϕ value is rotated to place this branch cut behind the cylinder (shadowed from the plate edge).

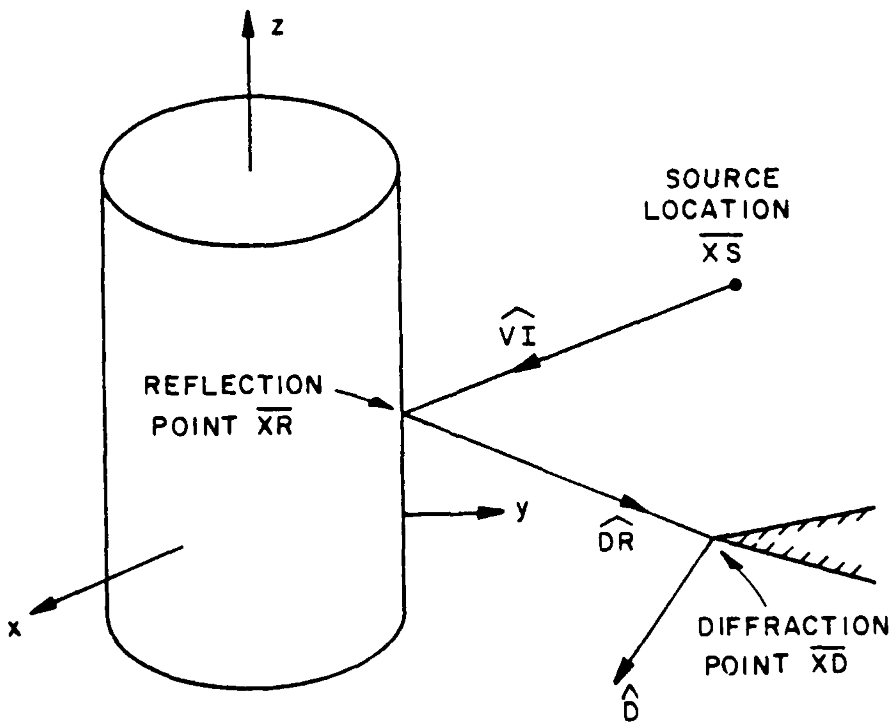


Figure 1. Illustration of Ray Reflected from Cylinder and then Diffracted by a Plate Edge

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The iteration begins with an initial reflected-diffracted ray which satisfies the laws of diffraction and reflection. Starting data are obtained in one of two ways. If a previous call to this routine (for the same plate edge and source) has successfully found the reflected-diffracted ray path, this previous path is used as starting data. Otherwise the starting diffraction point is defined on the corner of the edge closest to the cylinder. Then the corresponding reflection point is found by enforcing Snell's law. The first method is preferred to the second since, in general, far-field ray directions ($\hat{D}$) in subsequent calls to RFDFPT will not differ greatly. For example, in calculating a far-field pattern cut, the far-field θ and ϕ angles will differ by only a few degrees, and the closeness of the starting point will lead to fewer iterations in order to obtain convergence.

The path of the starting ray defines the initial cylinder reflection point ($\overline{XR}$) and the edge diffraction point ($\overline{XD}$). In almost every instance, the resulting radiation direction of this ray will not be the desired radiation direction. The angular difference between (θ,ϕ) of the starting ray (THOR, PHORP) and the (θ,ϕ) of the desired direction (THSR, PHSRP) is divided into a number of small angular steps $(\Delta\theta,\Delta\phi)$ = (DTSR, DPSR). The purpose of the iteration is to move the reflection and diffraction points from their initial positions in small steps corresponding to angular changes $(\Delta\theta,\Delta\phi)$ so that when the iteration is complete the resulting $\overline{XR}$ and $\overline{XD}$ will define the reflection and diffraction points that give the desired $\hat{D}$-directed ray. The number of steps to be taken (IVD) is determined from the starting data. Should convergence not be reached in IVD steps, the number of steps is doubled (up to 32 steps) and the iteration repeated. The doubling process is the outer loop of the flowchart. Should convergence be reached with IVD steps and the Snell's law error be significantly smaller than required, IVD for the plate and edge under consideration is halved prior to exiting the routine.

The iterations which step through the (θ,ϕ) angles by $(\Delta\theta,\Delta\phi)$ correspond to the inner loop of the flowchart. Each iteration has three steps:

(1) Compute the diffraction point ($\overline{XD}$) from known reflection point ($\overline{XR}$), source point ($\overline{XS}$) and edge unit vector ($\hat{V}$). This is done by a simple application of Snell's law. All the far-field calculations are contained in this subroutine, but, to determine the near-field diffraction point, subroutine DFPTWD is called.

(2) The change in cylinder elliptic angle (DV) and z coordinate (DU) are computed from a Taylor series expansion. The expansion requires the calculation of functions and partial

derivatives of equations defining elliptic angle (VR) and z coordinate (UR) in terms of the angles (θ,ϕ). The equations are given in reference A.

(3) The coordinates of $\overline{XR}$ are computed from the new values of UR and VR.

At the end of the prescribed number of iterations, the initial observation direction has been stepped slowly to the desired direction and the initial reflection-diffraction points have been stepped from their initial values to candidate reflection-diffraction points. Snell's law is then applied to the final reflection and final diffraction points to see if they qualify as the <u>bona fide</u> ray path. If the error is sufficiently small, the outer loop is exited. Otherwise, the number of steps is doubled, as described above. Should the routine not converge with 32 steps (the maximum number), a warning message is printed on LUPRNT.

This routine is called by RCLDPL (reflection from a cylinder, diffraction from a plate) and also by DPLRCL (diffraction from a plate, reflection from a cylinder). DPLRCL only calls this routine for the near-field case since, if the observation point and the source point are reversed, the ray path would be the same.

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
A	The x axis radius of the cylinder
B	The y axis radius of the cylinder
BCD	Diffraction limit for ray reflected by the cylinder and diffracted from the plate
D	The unit vector of the observation direction
DC	X,Y,Z components of diffracted ray propagation used in iteration
DCP	X,Y components of phi polarization unit vector for diffracted ray used in iteration
DCT	X,Y,Z components of theta polarization unit vector for diffracted ray used in iteration
DE	Dot product of diffracted ray direction and edge vector of edge ME

DOTP	Test parameter used to determine if reflection is legal
DPSR	Phi angle increment size
DR	X,Y,Z components of ray direction between reflection and diffraction points
DRM	Distance from reflection point to the diffraction point
DRP	Partial derivative of DR with respect to phi
DRT	Partial derivative of DR with respect to theta
DRU	Partial derivative of DR with respect to UR
DRV	Partial derivative of DR with respect to VR
DTSR	Theta angle increment size
DU	Change in UR for one iteration using Taylor series expansion
DV	Change in VR for one iteration using Taylor series expansion
ERC	Error detection variable
FI	Equation governing the law of reflection
FLDPT	The x,y,z components of the near-field observation point
FP	Partial derivative of FI with respect to phi
FT	Partial derivative of FI with respect to theta
FU	Partial derivative of FI with respect to UR
FV	Partial derivative of FI with respect to VR
GI	Equation governing the law of reflection

GP	Partial derivative of GI with respect to phi
GT	Partial derivative of GI with respect to theta
GU	Partial derivative of GI with respect to UR
GV	Partial derivative of GI with respect to VR
IVD	Stored number of steps used in iteration
LNRFLD	Flag to indicate near-field (LNRFLD = 1) or far-field (LNRFLD = 0) calculations were requested
LRDC	Set true if starting point data are available from previous pattern angle
ME	Edge on plate MP where diffraction occurs
MEP	Array which contains the number of edges on each plate
MP	Plate where diffraction occurs
PHCR	Phi component of diffracted ray direction used in iteration
PHOR	Phi component of diffracted ray direction from previous time RFDFPT was called (or present value for next time routine is called)
PHORP,PHSPR	Phi angle of diffracted ray direction in rotated RCS system (branch cut placed behind cylinder)
PHSR	The phi angle of the observation direction
PHWR	Branch cut displacement angle for the diffraction point along edge ME of plate MP
PI	π
SNM	Normalization constant for cylinder tangent
SNPX	Partial derivative of SNX with respect to angle VR

SNPY	Partial derivative of SNY with respect to angle VR
SNX	X component of normal to cylinder
SNY	Y component of normal to cylinder
STP	Number of steps used in iteration
THCR	Theta component of diffracted ray direction used in iteration
THOR	Theta component of diffracted ray direction from previous time RFDFPT was called (or for next time routine is called)
THSR	The theta angle of the observation direction
TPI	2π
UCD	Z component of reflection point location on cylinder for cylinder-reflected ray diffracted by a corner on edge ME of plate MP used as the starting point if previous data do not exist
UR	Z component of reflection point location on cylinder
URO	Stored components defining z component of starting reflection point locations on cylinder
V	Matrix of edge unit vectors for all edges of all plates
VCD	Elliptical angle defining reflection point on cylinder (2-D) for ray which is reflected by cylinder and diffracted by a corner on edge ME of plate MP used for the starting point location if previous data do not exist
VI	X,Y,Z components of unit vector of ray incident on cylinder
VIM	Distance from source to reflection point

VIU	Partial derivative of VI with respect to UR
VIV	Partial derivative of VI with respect to angle VR
VR	Elliptical angle defining reflection point on cylinder (2-D)
VRO	Stored elliptical angles defining starting reflection point locations on cylinder
X	Matrix which contains all the corner locations for all the plates
XD	X,Y,Z components of diffraction point location
XR	X,Y,Z components of reflection point location on cylinder
XS	The x,y,z components of the source location in RCS

5. I/O VARIABLES:

A. INPUT

INPUT	LOCATION
A	/GEOMEL/
B	/GEOMEL/
BCD	/BNDRCL/
D	/DIR/
DE	F.P.
FLDPT	/NEAR/
LNRFLD	/NEAR/
LRDC	F.P.
LUPRNT	/ADEBUG/
ME	F.P.
MEP	/GEOPLA/

MP	F.P.
PHSR	/DIR/
PHWR	/BRNPHW/
PI	/PIS/
THSR	/DIR/
TPI	/PIS/
UCD	/BNDRCL/
V	/GEOPLA/
VCD	/BNDRCL/
X	/GEOPLA/
XS	/SORINF/

B.

OUTPUT	LOCATION
DOTP	F.P.
DR	F.P.
DRM	F.P.
LRDC	F.P.
SNM	F.P.
VI	F.P.
VIM	F.P.
VR	F.P.
XD	F.P.
XR	F.P.

6. CALLING ROUTINES:

DPLRCL

RCLDPL

7. CALLED ROUTINES:

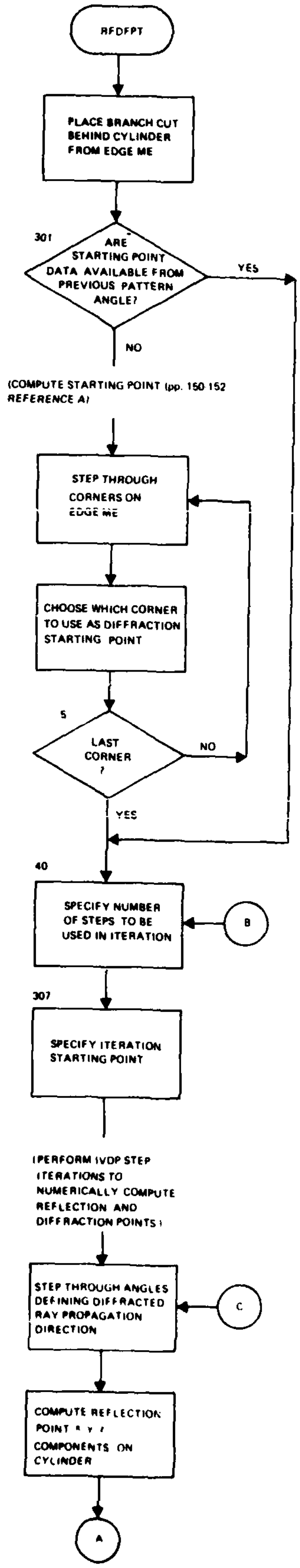
BTAN2

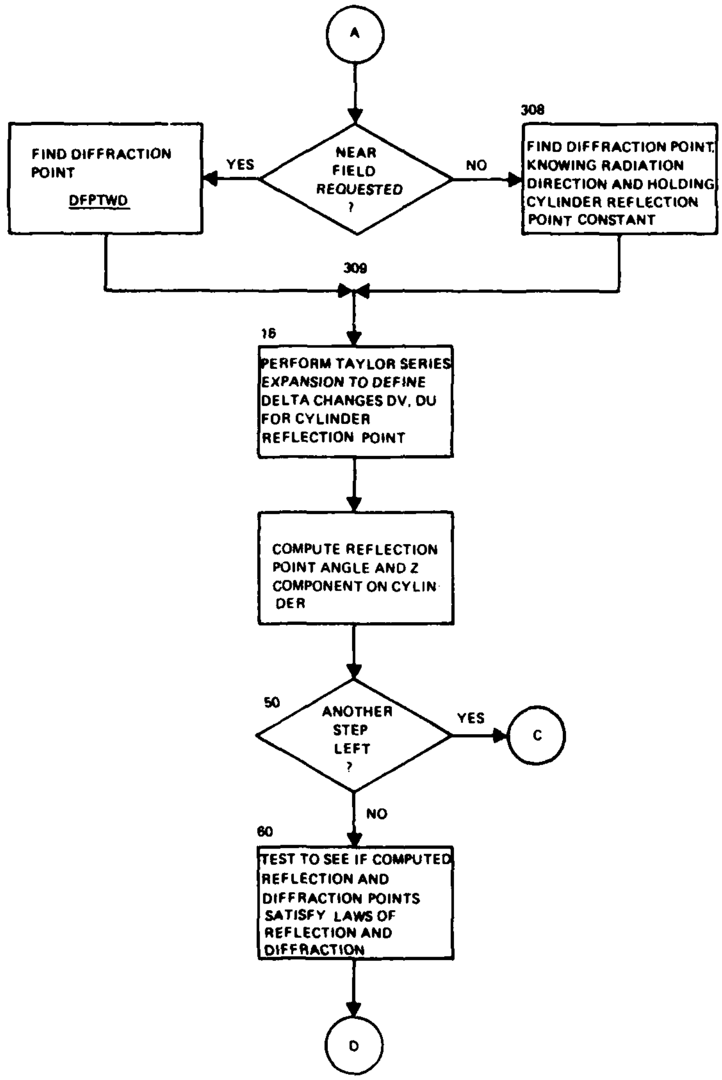
DFPTWD

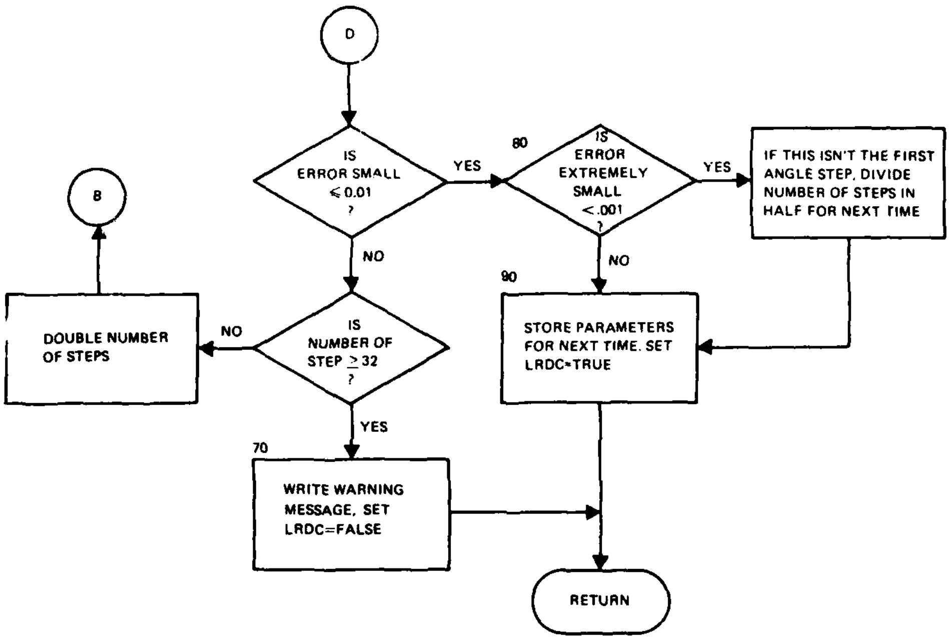
NFD

8. REFERENCE:

A. R. J. Marhefka, "Analysis of Aircraft Wing-Mounted Antenna Patterns," Report 2902-25, June 1976, The Ohio State University ElectroScience Laboratory, Department of Electrical Engineering; prepared under Grant No. NGL 36-008-138 for National Aeronautics and Space Administration.


RFDFPT
PLACE BRANCH CUT BEHIND CYLINDER FROM EDGE ME
301
ARE STARTING POINT DATA AVAILABLE FROM PREVIOUS PATTERN ANGLE?
YES
NO
(COMPUTE STARTING POINT (pp. 150 152 REFERENCE A)
STEP THROUGH CORNERS ON EDGE ME
CHOOSE WHICH CORNER TO USE AS DIFFRACTION STARTING POINT
5
LAST CORNER ?
NO
YES
40
SPECIFY NUMBER OF STEPS TO BE USED IN ITERATION
B
307
SPECIFY ITERATION STARTING POINT
(PERFORM IVDP STEP ITERATIONS TO NUMERICALLY COMPUTE REFLECTION AND DIFFRACTION POINTS)
STEP THROUGH ANGLES DEFINING DIFFRACTED RAY PROPAGATION DIRECTION
C
COMPUTE REFLECTION POINT x y z COMPONENTS ON CYLINDER
A


A
308
FIND DIFFRACTION POINT
DFPTWD
YES
NEAR FIELD REQUESTED ?
NO
FIND DIFFRACTION POINT, KNOWING RADIATION DIRECTION AND HOLDING CYLINDER REFLECTION POINT CONSTANT
309
16
PERFORM TAYLOR SERIES EXPANSION TO DEFINE DELTA CHANGES DV, DU FOR CYLINDER REFLECTION POINT
COMPUTE REFLECTION POINT ANGLE AND Z COMPONENT ON CYLINDER
50
ANOTHER STEP LEFT ?
YES
C
NO
60
TEST TO SEE IF COMPUTED REFLECTION AND DIFFRACTION POINTS SATISFY LAWS OF REFLECTION AND DIFFRACTION
D


D
IS ERROR SMALL ≤ 0.01 ?
YES
80
IS ERROR EXTREMELY SMALL < .001 ?
YES
IF THIS ISN'T THE FIRST ANGLE STEP, DIVIDE NUMBER OF STEPS IN HALF FOR NEXT TIME
NO
NO
90
B
DOUBLE NUMBER OF STEPS
NO
IS NUMBER OF STEP ≥ 32 ?
STORE PARAMETERS FOR NEXT TIME. SET LRDC=TRUE
YES
70
WRITE WARNING MESSAGE, SET LRDC=FALSE
RETURN

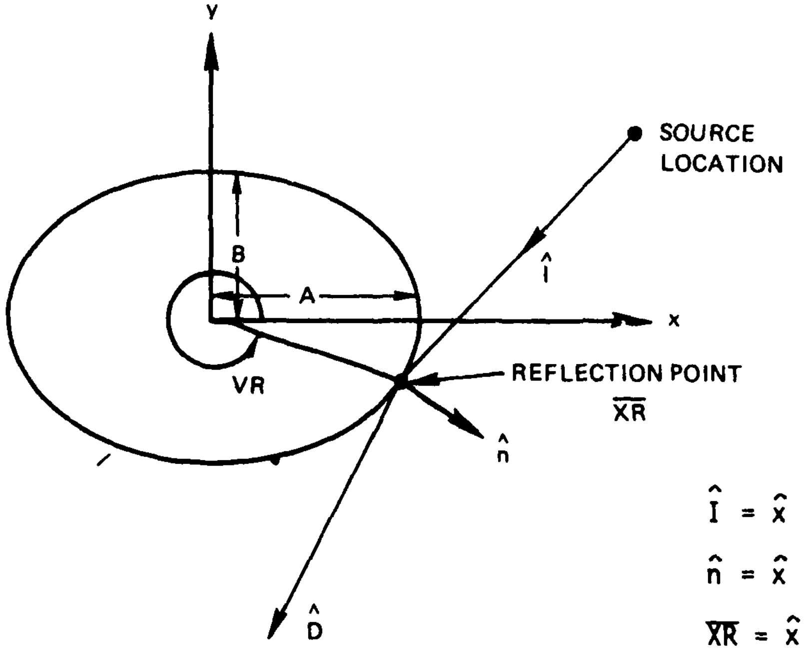
1. NAME: RFPTCL (GTD)

2. PURPOSE: To calculate the reflection point on the elliptic cylinder for a source ray reflected in a given direction. The routine also computes cylinder reflection points for source rays that are reflected by a given plate and then reflected by the cylinder.

3. METHOD: Figures 1, 2 and 3 show the geometry involved. The reflection point for a ray reflected in a direction defined by the phi angle PHSR is calculated via an iterative process. The routine starts with the tangent ray nearest to the reflected ray direction (or other nearby reflected ray whose reflection point is known) and steps along the cylinder surface, calculating the approximate reflection point for each reflected ray phi angle PHPR (which is stepped from PHOR to PHSR in evenly spaced steps). Each reflection point calculation uses the previous reflection point as a reference. As long as the steps are sufficiently small, the approximation is accurate. The equations are based on a first order Taylor series approximation of the equation governing the laws of reflection. Further details are given on pages 102-104 of reference A. The point obtained at the end of the process is the estimated reflection point. The routine then takes the sum of dot products of the cylinder normal and the incident and reflected rays (which should be zero in order to satisfy the law of reflection). If it is larger than some minimal amount, the number of iteration steps for angle PHPR is doubled and the calculation is redone. If the error is much smaller than necessary, the number of steps used in the next calculation is divided by two.

Once a reflection point is calculated for a particular geometry, the elliptical angle defining the reflection point (VRO(MR)) is saved, along with the number of steps used to calculate it (IVD(MR)) for the next time RFPTCL is called for the same geometry. Since the next pattern angle is likely to be quite close to the previous one, this gives the computer a good starting point in defining the next reflection point, hence minimizing computer time. LRFC is a logical variable which if true tells the user that there are data from the previous pattern angle available to compute the next reflection point. If a reflection does not occur, LRFC is set false, and the next time the routine is called, it will start at the nearest tangent point.

An important note to users is that if the same problem is run with a different starting angle or with a different angle increment, the answers may not be precisely the same due to the iterative approach.

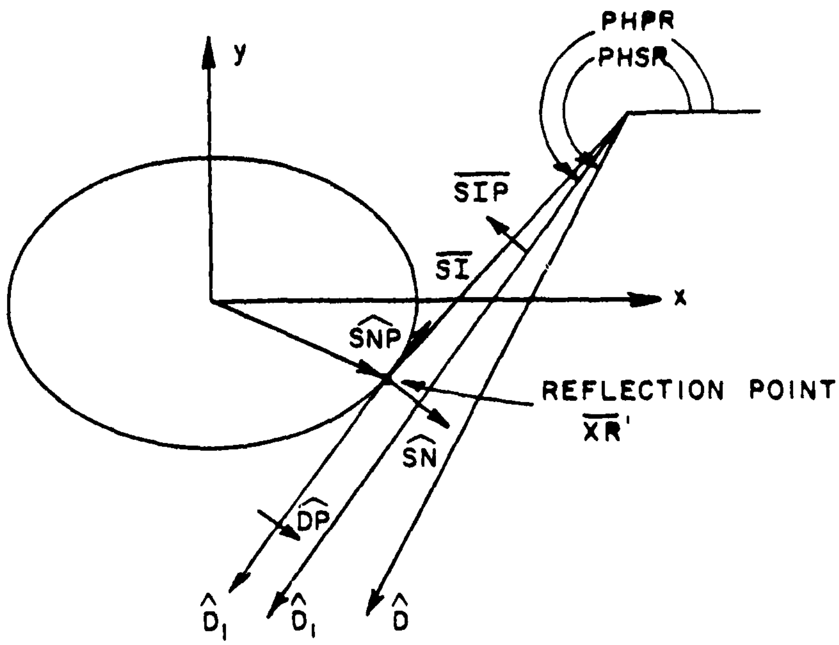


$\hat{I} = \hat{x}\ SIX + \hat{y}\ SIY$

$\hat{n} = \hat{x}\ SNX + \hat{y}\ SNY$

$\overline{XR} = \hat{x}\ A \cos VR + \hat{y}\ B \sin VR$

Figure 1. Illustration of Cylinder Reflection Point



$\hat{D}_1 = \hat{x}\ DX + \hat{y}\ DPY$

$\widehat{DP} = \hat{x}\ DPX + \hat{y}\ DPY$

$\overline{SN} = \hat{x}\ SNX + \hat{y}\ SNY$

$\overline{SNP} = \hat{x}\ SNPX + \hat{y}\ SNPY$

$\overline{SI} = \hat{x}\ SIX + \hat{y}\ SIY$

$\overline{SIP} = \hat{x}\ SIPX + \hat{y}\ SIPY$

$\overline{XR}'$ = reflection point for ray with reflected phi angle PHPR

$= \hat{x}\ A\ CSV + \hat{y}\ B\ SNV$

Figure 2. Geometry for Calculating Reflection Point

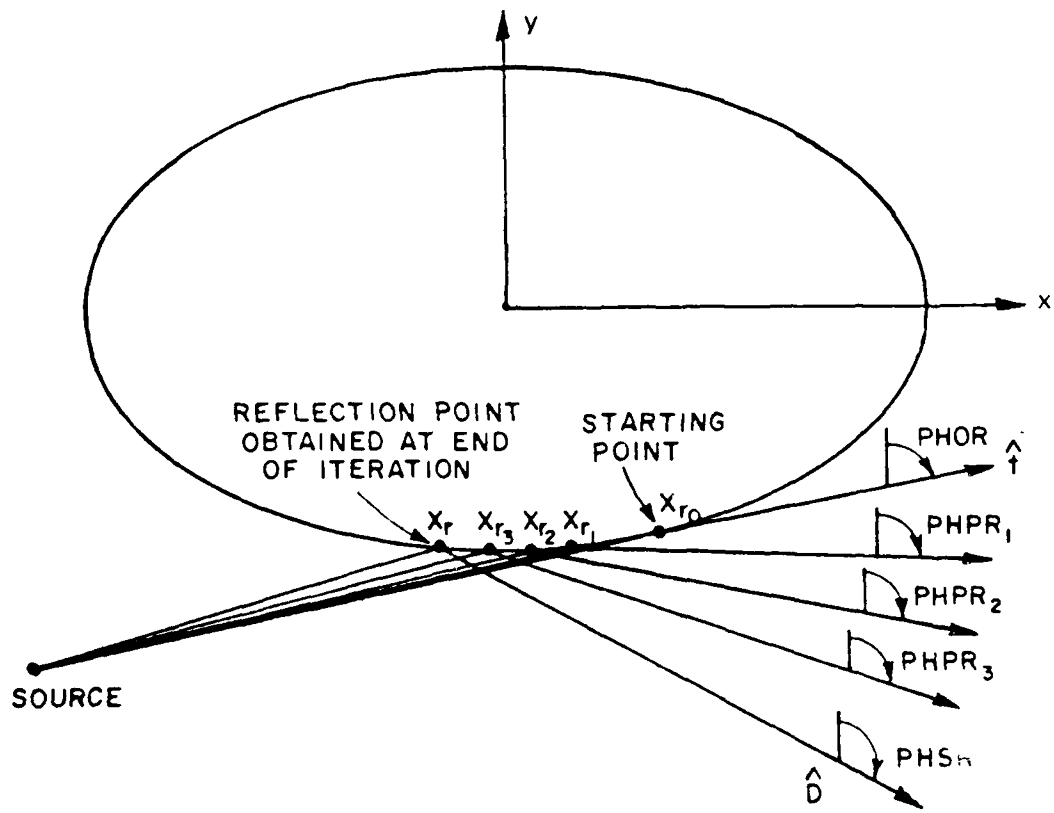


Figure 3. Illustration of Iterative Method Used in Computing the Cylinder Reflection Point

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
A	Radius of cylinder along the x axis
B	Radius of cylinder along the y axis
BTI	This defines unit vectors for the two rays reflected by each plate and tangent to the cylinder. The unit vector for the source ray reflected from plate MP tangent to tangent point 1 is given by:

$$T1 = \hat{x} * BTI(MP,1) + \hat{y} * BTI(MP,2)$$

	The unit vector for the source ray reflected from plate MP tangent to tangent point 2 is given by:
	$\hat{T2} = \hat{x} * BTI(MP,3) + \hat{y} * BTI(MP,4)$
BTS	This defines unit vectors of the two source rays tangent to the cylinder. The unit vector for the source ray tangent to tangent point 1 is given by:
	$\hat{T1} = \hat{x} * BTS(1) + \hat{y} * BTS(2)$
	The unit vector for the source ray tangent to tangent point 2 is given by:
	$\hat{T2} = \hat{x} * BTS(3) + \hat{y} * BTS(4)$
CPP	Cosine of PHPR
CPS	Cosine of PHSR
CSV	Cosine of VR
DD	Normalization constant for reflection point normal vector
DOTP	One half the difference between the dot products of the reflected ray direction and cylinder unit normal and the incident ray direction and cylinder unit normal
DPSR	Size of angle step used in iteration
DPX,DPY	X and Y components of partial derivative of reflected ray direction with respect to phi observation angle
DR	Dot product of incident ray unit vector and cylinder unit normal
DS	Dot product of reflected ray propagation direction unit vector and cylinder unit normal
DV	Change in angle VR

DVB	Partial derivative of the reflection law equation (FI) with respect to elliptical angle VR
DVT	Partial derivative of the reflection law equation (FI) with respect to the phi angle of the observation direction
DX,DY	X and Y components of unit vector of reflected ray (direction defined by angle PHPR) in RCS
ERC	Error parameter (sum of DS and DR)
ERCA	Absolute value of ERC
FI	Equation satisfying the law of reflection
IVD	Number of iterations used to find reflection point the last time RFPTCL was called for plate MP
IVDM	Number of steps used in iteration
LRFC	(Entering routine) set true if reflection occurred last time REFCYL was called. (LRFC set true when leaving routine if reflection occurred this time)
MP	Used to specify whether source or source image is used MP=0 designates source MP>0 designates source image for reflection from plate MP
MPXR	Maximum number of plates present
MR	Index variable (MP+MPXR+I) for storing data for next call to RFPTCL
PHE	Phi angle between reflected ray direction and tangent point 2
PHEP	Phi angle between reflected ray direction and tangent point 1
PHIR	Phi component of source location in RCS

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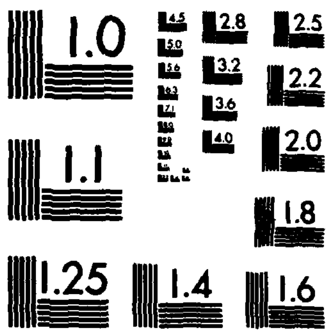


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

PHOR	Reflected ray phi angle (stored as starting point parameter for next time routine is called)
PHORB	Phi angle defining ray tangent to tangent point 1
PHORP	Phi angle of cylinder reflected ray direction in rotated RCS
PHPR	Reflected ray phi angle (iterated from PHOR to PHSR)
PHSPR	Phi angle defining reflected ray direction in rotated RCS
PHSR	Phi component of reflected ray propagation direction in RCS
PI	π
S	Distance from source to reflection point in x-y plane
SIPX,SIPY	X and Y components of partial derivative of incident ray vector with respect to elliptical angle VR
SIX,SIY	X and Y components of incident ray propagation vector in RCS (not always normalized)
SNPX,SNPY	X and Y components of partial derivative of cylinder normal at reflection point with respect to elliptical angle VR
SNV	Sine of VR
SNX,SNY	X and Y components of ray normal to cylinder reflection point in RCS (not always normalized)
SPP	Sine of PHPR
SPS	Sine of PHSR
STP	Number of steps used in iteration
TPI	2π

VR	Elliptical angle defining reflection point in RCS x-y plane
VRO	Elliptical angles defining tangent points for source ray (or source ray reflected from plate) tangent to cylinder
VTI	Array of elliptical angles defining for each plate the two tangent points on the cylinder for rays which are reflected from that plate
VTS	Consists of two elliptical angles defining the two tangent points on the cylinder from the source
XI	Array which contains the source image locations in wavelengths for all plate single and double reflections
XIS	Source location
XS	X,Y and Z components of source location

5. I/O VARIABLES:

A. INPUT

INPUT	LOCATION
A	/GEOMEL/
B	/GEOMEL/
BTI	/BNDICL/
BTS	/BNDSCL/
LRFC	F.P.
LUPRNT	/ADEBUG/
MP	F.P.
MPXR	/GROUND/
PHSR	F.P.
PI	/PIS/
TPI	/PIS/

VTI	/BNDICL/
VTS	/BNDSCL/
XI	/IMAINF/
XS	/SORINF/

B. OUTPUT — LOCATION

DD	F.P.
DOTP	F.P.
LRFC	F.P.
S	F.P.
VR	F.P.

6. CALLING ROUTINES:

RCLRPL

REFCYL

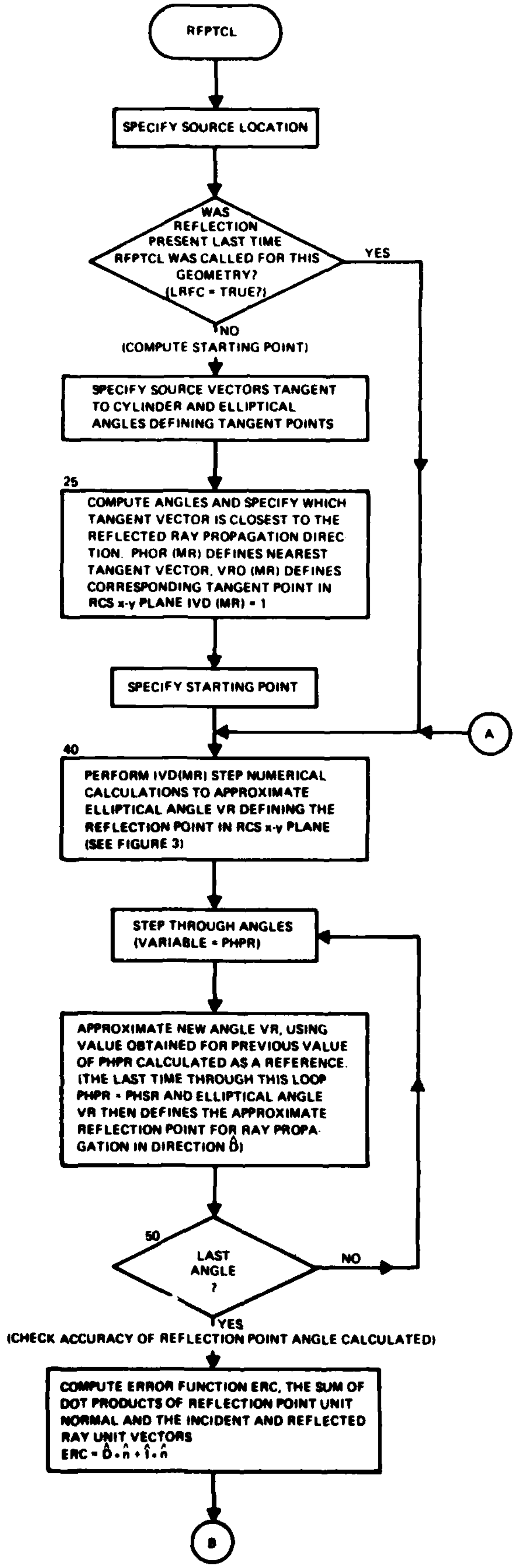
RPLRCL

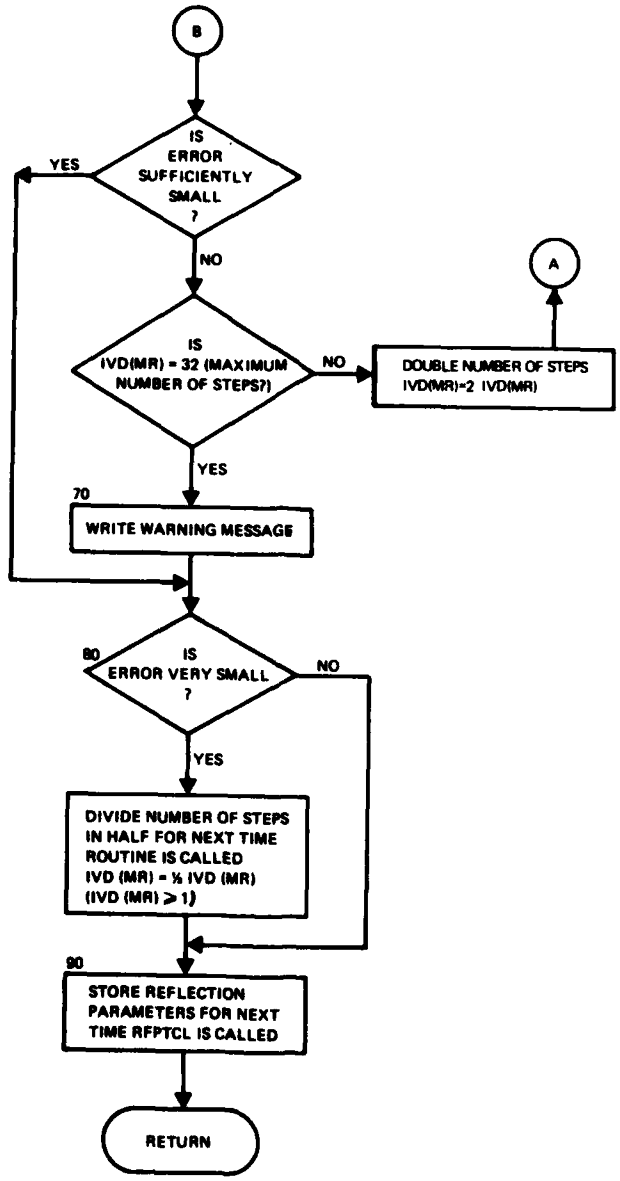
7. CALLED ROUTINE:

BTAN2

8. REFERENCE:

A. R. J. Marhefka, "Analysis of Aircraft Wing-Mounted Antenna Patterns," Report 2902-25, June 1976, The Ohio State University ElectroScience Laboratory, Department of Electrical Engineering; prepared under Grant No. NGL 36-008-138 for National Aeronautics and Space Administration.


RFPTCL
SPECIFY SOURCE LOCATION
WAS REFLECTION PRESENT LAST TIME RFPTCL WAS CALLED FOR THIS GEOMETRY? (LRFC = TRUE?)
YES
NO
(COMPUTE STARTING POINT)
SPECIFY SOURCE VECTORS TANGENT TO CYLINDER AND ELLIPTICAL ANGLES DEFINING TANGENT POINTS
25
COMPUTE ANGLES AND SPECIFY WHICH TANGENT VECTOR IS CLOSEST TO THE REFLECTED RAY PROPAGATION DIRECTION. PHOR (MR) DEFINES NEAREST TANGENT VECTOR, VRO (MR) DEFINES CORRESPONDING TANGENT POINT IN RCS x-y PLANE IVD (MR) = 1
SPECIFY STARTING POINT
A
40
PERFORM IVD(MR) STEP NUMERICAL CALCULATIONS TO APPROXIMATE ELLIPTICAL ANGLE VR DEFINING THE REFLECTION POINT IN RCS x-y PLANE (SEE FIGURE 3)
STEP THROUGH ANGLES (VARIABLE = PHPR)
APPROXIMATE NEW ANGLE VR, USING VALUE OBTAINED FOR PREVIOUS VALUE OF PHPR CALCULATED AS A REFERENCE. (THE LAST TIME THROUGH THIS LOOP PHPR = PHSR AND ELLIPTICAL ANGLE VR THEN DEFINES THE APPROXIMATE REFLECTION POINT FOR RAY PROPAGATION IN DIRECTION D̂)
50
LAST ANGLE ?
NO
YES
(CHECK ACCURACY OF REFLECTION POINT ANGLE CALCULATED)
COMPUTE ERROR FUNCTION ERC, THE SUM OF DOT PRODUCTS OF REFLECTION POINT UNIT NORMAL AND THE INCIDENT AND REFLECTED RAY UNIT VECTORS
ERC = D̂·n̂ + Î·n̂
B


B
IS ERROR SUFFICIENTLY SMALL ?
YES
NO
IS IVD(MR) = 32 (MAXIMUM NUMBER OF STEPS?)
NO
DOUBLE NUMBER OF STEPS IVD(MR)=2 IVD(MR)
A
YES
70
WRITE WARNING MESSAGE
80
IS ERROR VERY SMALL ?
NO
YES
DIVIDE NUMBER OF STEPS IN HALF FOR NEXT TIME ROUTINE IS CALLED IVD (MR) = ½ IVD (MR) (IVD (MR) ≥ 1)
90
STORE REFLECTION PARAMETERS FOR NEXT TIME RFPTCL IS CALLED
RETURN

1. NAME: ROMBNT (GTD, MOM)

2. PURPOSE: To numerically compute the integral of the function exp $(-jkr)/kr$ for a wire segment or $[(1/kr)^3 + j(1/kr)^2]$ exp $(-jkr)$ for a patch observation point.

3. METHOD: To evaluate the field due to a segment, a local cylindrical coordinate system is defined with origin at the center of the segment and z axis in the segment direction. This geometry is illustrated in the discussion of subroutine TNEFLD. Subroutine ROMBNT is called by subroutines TNEFLD and SOURCE to evaluate the integral

$$G = \int_{-k\Delta/2}^{k\Delta/2} \frac{e^{-jkr}}{kr}\, d(kz)$$

where

$$r = \left[\rho'^2 + (z - z')^2\right]^{1/2}$$

and other symbols are defined in the discussion of subroutine TNEFLD. To evaluate the magnetic field at a patch observation point, this subroutine is called by the subroutine TNHFLD to evaluate the integral

$$G = \int_{-k\Delta/2}^{k\Delta/2} \left[\frac{1}{(kr)^3} + \frac{j}{(kr)^2}\right] e^{-jkr}\, d(kz)$$

The numerical integration technique of Romberg integration with variable interval width is used. The Romberg integration formula is obtained from the trapezoidal formula by an iterative procedure (see reference A). The trapezoidal rule for integration of the function f(x) over an interval (a, b) using 2^k subintervals is

$$T_{0k} = (b - a)/N \left[1/2\, f_0 + f_1 + \ldots + f_{N-1} + 1/2\, f_N\right]$$

where

$$N = 2^k$$

$$f_i = f(x_i)$$

$$x_i = a + i\ (b - a)/N$$

These trapezoidal rule answers are then used in the iterative formula

$$T_{m,n} = 1/(4^m - 1) \left| 4^m T_{m-1,n+1} - T_{m-1,n} \right|$$

The results T_{mn} may be arranged in a triangular matrix of the form

$$\begin{array}{lll} T_{00} & & \\ T_{01} & T_{10} & \\ T_{02} & T_{11} & T_{20} \end{array}$$

where the elements in the first column, T_{0k}, represent the trapezoidal rule results and the elements in the diagonal, T_{k0}, are the Romberg integration results for 2^k subintervals.

Convergence to increasingly accurate answers takes place down the first column and the diagonal as well as toward the right along the rows. The row convergence generally provides a more realistic indication of error magnitude than two successive trapezoidal rule or Romberg answers.

This convergence along the rows is used to determine the interval width in the variable interval width scheme. The complete integration interval is first divided into a minimum number of subintervals (presently set to one) and T_{00}, T_{01}, and T_{10} are computed on the first subinterval. The relative difference of T_{01} and T_{10} is then computed and if less than the error criterion, R_x, T_{10} is accepted as the integral over that interval and integration proceeds to the next interval. If the difference of T_{01} and T_{10} is too great, T_{02}, T_{11}, and T_{20} are computed. The relative difference of T_{11} and T_{20} is then computed and if less than R_x, T_{20} is accepted as the integral over the subinterval. If the difference of T_{11} and T_{20}

is too great, the subinterval is divided in half and the process repeated starting with T_{00} for the new left-hand subinterval. The subinterval is repeatedly halved until convergence to less than R_x is found. The process is repeated for successive subintervals until the right-hand side of the integration interval is reached. When convergence has been obtained with a given subinterval size, the routine attempts doubling the subinterval size for a few times to maintain the largest subinterval size that will give the required accuracy. Thus, the routine will use many points in a rapidly changing region of a function and few points where the function is smoothly varying.

Since the function to be integrated is complex, the convergence of both real and imaginary parts is tested and both must be less than R_x. The same subinterval sizes are used for real and imaginary parts.

When the field of a segment is being computed at the segment's own center the length r becomes

$$r = \left[b^2 + (z - z')^2 \right]^{1/2}$$

where b is the wire radius. For small values of b, the real part of the integrand is sharply peaked and hence difficult to integrate numerically. Therefore, the integral is divided into the components

$$G' = \int_{-k\Delta/2}^{k\Delta/2} \frac{e^{-jkr} - 1}{kr} \, d(kz)$$

$$G'' = \int_{-k\Delta/2}^{k\Delta/2} \frac{1}{kr} \, d(kz)$$

$$G = G' + G''$$

G' must be computed numerically, however the integrand is no longer peaked. G'', which contains the sharp peak, can be computed as

$$G'' = 2\log\left[(\sqrt{b^2 + \Delta^2} + \Delta)/b \right]$$

To further reduce integration time for the self term, the integral of G' is computed from $-k\Delta/2$ to 0 and the result doubled to obtain G'.

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
BK	Wire radius, b
DZ	Subinterval size on which T_{00}, T_{01}, ...are computed
DZOT	0.5 DZ
EL1	$-k\Delta/2$
EL2	$k\Delta/2$
EP	Tolerance for ending the integration interval $k\Delta$/NM*10
FNM	Real number equivalent of NM
FNS	Real number equivalent of NS
G1I	Imaginary part of f_1
G1R	Real part of f_i
G2I	Imaginary part of f_2
G2R	Real part of f_2
G3I	Imaginary part of f_3
G3R	Real part of f_3
G4I	Imaginary part of f_4
G4R	Real part of f_4
G5I	Imaginary part of f_5
G5R	Real part of f_5

IJ	Indicates self-term integration when equal to zero, or patch observation point when equal to one
NM	$65536 = 2^{16}$
NS	Present subinterval size is $k\Delta/NS$
NT	Counter to control increasing of subinterval size
NTS	Larger values retard increasing of subinterval size
NX	Maximum allowed subinterval size is $k\Delta/NX$
RX	R_x
SGI	Imaginary part of G
SGR	Real part of G
SS	Δ
TE1I	Relative difference of T_{01} and T_{10} for imaginary part
TE1R	Relative difference of T_{01} and T_{10} for real part
TE2I	Relative difference of T_{11} and T_{20} for imaginary part
TE2R	Relative difference of T_{11} and T_{20} for real part
T00I	Imaginary part of T_{00}
T00R	Real part of T_{00}
T01I	Imaginary part of T_{01}
T01R	Real part of T_{01}
T02I	Imaginary part of T_{02}
T02R	Real part of T_{02}
T10I	Imaginary part of T_{10}

T10R	Real part of T_{10}
T11I	Imaginary part of T_{11}
T11R	Real part of T_{11}
T20I	Imaginary part of T_{20}
T20R	Real part of T_{20}
Z	Integration variable at left-hand side of subinterval
ZE	$k\Delta/2$
ZEND	$k\Delta/2$ - EP (EP = tolerance term)
ZP	Integration variable

5. I/O VARIABLES:

A. INPUT	LOCATION
BK	F.P.
EL1	F.P.
EL2	F.P.
IJ	F.P.
B. OUTPUT	LOCATION
ICALL	/ADEBUG/
NUMWRD	/ADEBUG/
SGI	F.P.
SGR	F.P.

6. CALLING ROUTINES:*

SOURCE (2)

TNEFLD (3)

TNHFLD (3)

*2-GTD
3-MOM

7. CALLED ROUTINES:

ASSIGN

CNVTST

NTGRAN

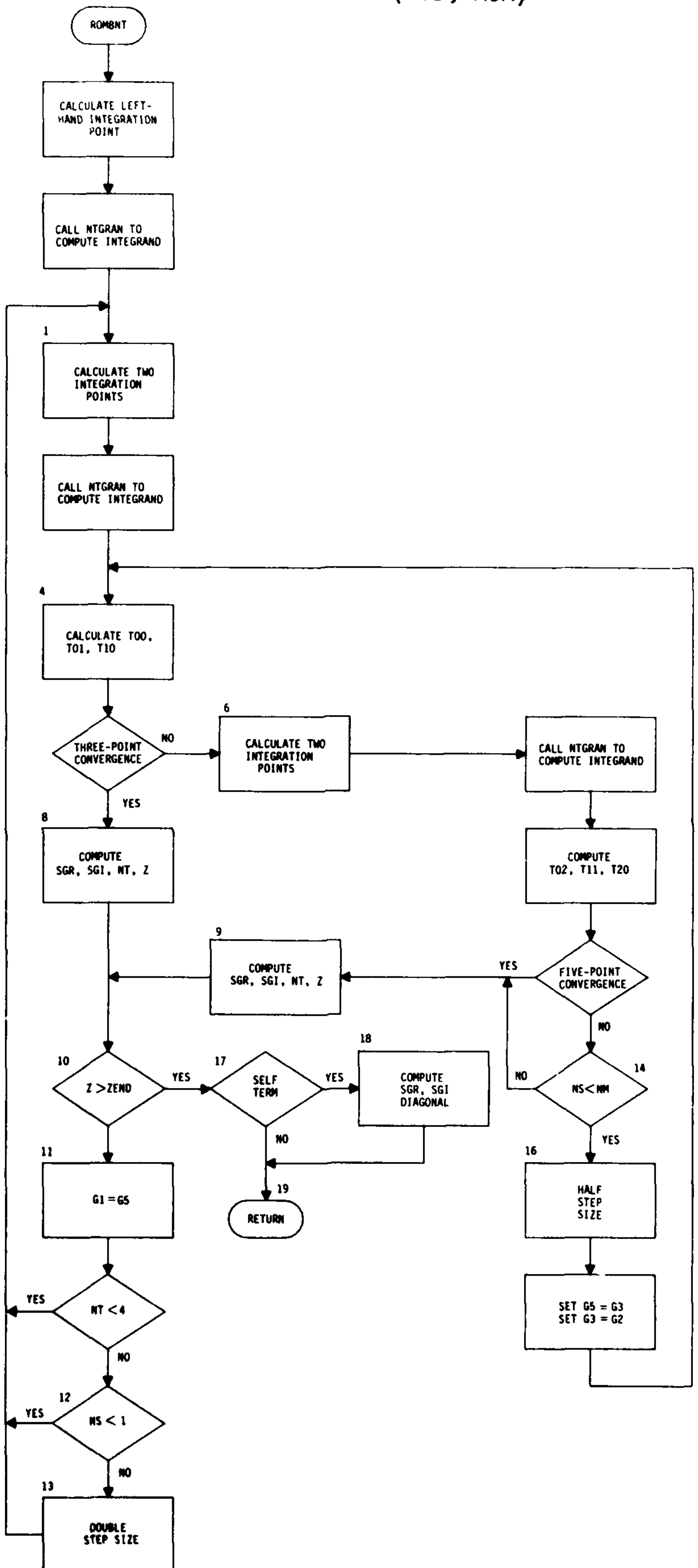
STATIN

STATOT

WLKBCK

8. REFERENCES:

A. A. Ralston, "A First Course in Numerical Analysis," McGraw-Hill, 1965, p. 212.


ROMBNT
CALCULATE LEFT-HAND INTEGRATION POINT
CALL NTGRAN TO COMPUTE INTEGRAND
1
CALCULATE TWO INTEGRATION POINTS
CALL NTGRAN TO COMPUTE INTEGRAND
4
CALCULATE T00, T01, T10
THREE-POINT CONVERGENCE
NO
6
CALCULATE TWO INTEGRATION POINTS
CALL NTGRAN TO COMPUTE INTEGRAND
YES
8
COMPUTE SGR, SGI, NT, Z
COMPUTE T02, T11, T20
9
COMPUTE SGR, SGI, NT, Z
YES
FIVE-POINT CONVERGENCE
NO
10
Z >ZEND
YES
17
SELF TERM
YES
18
COMPUTE SGR, SGI DIAGONAL
NO
14
NS<NM
NO
YES
11
G1 = G5
19
RETURN
16
HALF STEP SIZE
SET G5 = G3
SET G3 = G2
YES
NT < 4
NO
12
YES
NS < 1
NO
13
DOUBLE STEP SIZE

1. NAME: ROTATE (GTD, INPUT)

2. PURPOSE: To rotate a point to or from the origin of a given coordinate system.

3. METHOD: The coordinates of a point rotated in a given coordinate system are given by

$$\begin{bmatrix} X' \\ Y' \\ Z' \end{bmatrix} = \begin{bmatrix} R_Z \end{bmatrix} \cdot \begin{bmatrix} R_y \end{bmatrix} \cdot \begin{bmatrix} R_x \end{bmatrix} \cdot \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}$$

where

$$\begin{bmatrix} R_x \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\Psi & -\sin\Psi \\ 0 & \sin\Psi & \cos\Psi \end{bmatrix}$$

$$\begin{bmatrix} R_y \end{bmatrix} = \begin{bmatrix} \cos\theta & 0 & \sin\theta \\ 0 & 1 & 0 \\ -\sin\theta & 0 & \cos\theta \end{bmatrix}$$

$$\begin{bmatrix} R_z \end{bmatrix} = \begin{bmatrix} \cos\phi & -\sin\phi & 0 \\ \sin\phi & \cos\phi & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

and Ψ, θ, ϕ are the rotation angles about the x, y, and z axis respectively.

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
A_{nm}	The components of the rotation matrix
CP	$\cos\phi$
CS	$\cos\Psi$
CT	$\cos\theta$
NOP	Operation code to designate rotation from or to the origin
PHI	ϕ, the rotation about the z axis

PHISV	Saved value of PHI
PSI	Ψ, the rotation about the x axis
PSISV	Saved value of PSI
RX,RY,RZ	Rotation angle about the x, y, and z axis, respectively
SP	$\sin\phi$
SS	$\sin\Psi$
ST	$\sin\theta$
THETA	θ, the rotation about the y axis
THTSV	Saved value of THETA
X,Y,Z	Coordinates of input/output variables to be changed

5. I/O VARIABLES

A. INPUT	LOCATION
ISOFF	/ADEBUG/
NOP	F.P.
RX,RY,RZ	F.P.
X,Y,Z	F.P.

B. OUTPUT	LOCATION
X,Y,Z	F.P.

6. CALLING ROUTINES:*

COORDS (1)

CYAXIS (2)

GTDCS (1)

PATCH (1)

WYRDRV (1)

*1-INPUT
2-GTD

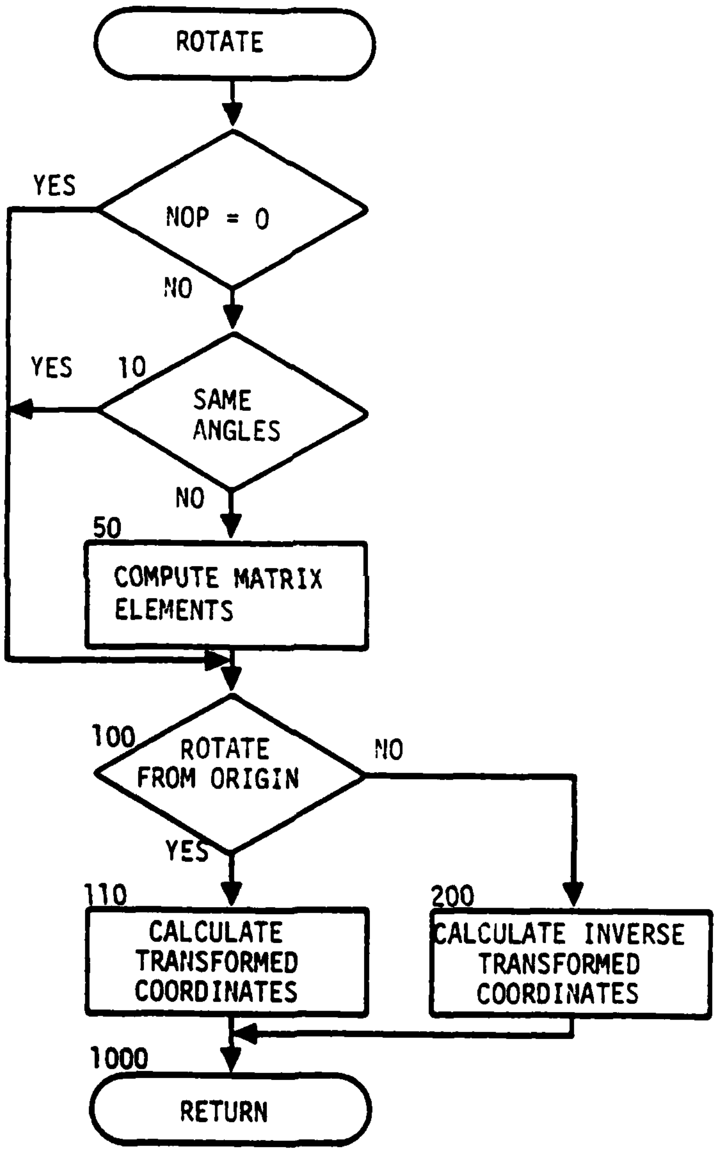
7. CALLED ROUTINES:

ASSIGN

STATIN

STATOT

WLKBCK


ROTATE
NOP = 0
YES
NO
10
SAME ANGLES
YES
NO
50
COMPUTE MATRIX ELEMENTS
100
ROTATE FROM ORIGIN
NO
YES
110
CALCULATE TRANSFORMED COORDINATES
200
CALCULATE INVERSE TRANSFORMED COORDINATES
1000
RETURN

1. NAME: ROTRAN (GTD)

2. PURPOSE: To transform and rotate a point or vector defined in the global coordinate system (as stored in the segment table SEGTBL) to the cylinder-centered reference coordinate system (RCS) used for the GTD calculations.

3. METHOD: The point $\bar{X}_x$ defined in the global coordinate system may be represented by point $\bar{X}_{rt}$ in the cylinder-centered RCS where (refer to figure 1):

$$\bar{X}_{rt} = \left[V_{cl}\right]\bar{X}_t, \text{ where } \bar{X}_t = \bar{X}_x - \bar{X}_o$$

or

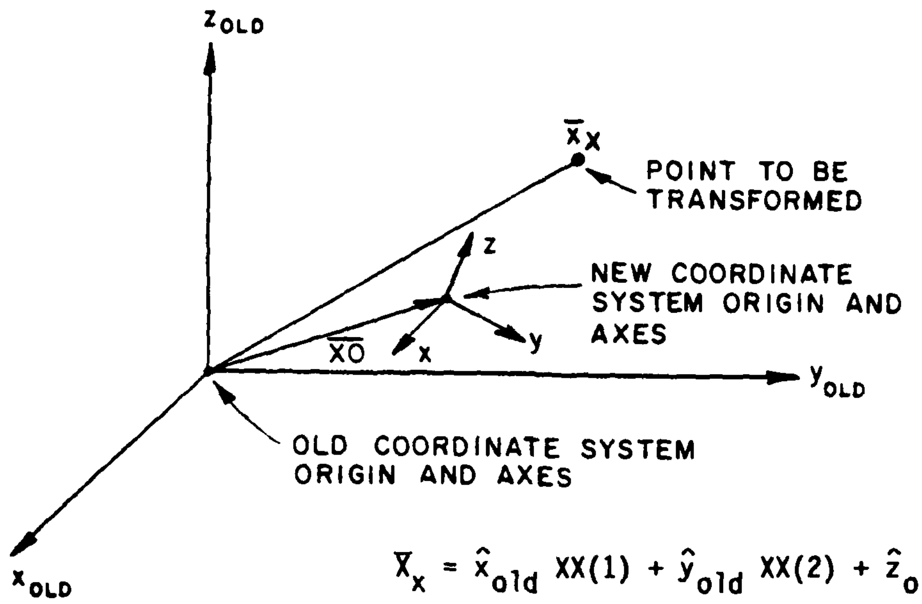
$$\begin{bmatrix} XRT(1) \\ XRT(2) \\ XRT(3) \end{bmatrix} = \begin{bmatrix} XCL(1) & XCL(2) & XCL(3) \\ YCL(1) & YCL(2) & YCL(3) \\ ZCL(1) & ZCL(2) & ZCL(3) \end{bmatrix} \begin{bmatrix} XX(1) - XO(1) \\ XX(2) - XO(2) \\ XX(3) - XO(3) \end{bmatrix}$$

where $\bar{X}_0$ is the location of the cylinder-centered RCS origin defined in the global coordinate system and $\hat{x}$, $\hat{y}$, $\hat{z}$ are unit vectors defining the cylinder centered RCS axes in global coordinate system (g) components:

$$\hat{x} = \hat{x}_g\ XCL(1) + \hat{y}_g\ XCL(2) + \hat{z}_g\ XCL(3)$$

$$\hat{y} = \hat{x}_g\ YCL(1) + \hat{y}_g\ YCL(2) + \hat{z}_g\ YCL(3)$$

$$\hat{z} = \hat{x}_g\ ZCL(1) + \hat{y}_g\ ZCL(2) + \hat{z}_g\ ZCL(3).$$



$$\bar{X}_x = \hat{x}_{old}\ XX(1) + \hat{y}_{old}\ XX(2) + \hat{z}_{old}\ XX(3)$$

$$\bar{X}_x = \hat{x}\ XRT(1) + \hat{y}\ XRT(2) + \hat{z}\ XRT(3)$$

Figure 1. Illustration of Old and New Reference Coordinate Systems

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
XCL	This defines the cylinder-centered reference coordinate system x axis unit vector in global system components
XO	X,Y, and Z components of the cylinder-centered reference coordinate system origin location defined in the global coordinate system
XRT	X,Y, and Z components of point location in RCS
XT	X,Y, and Z components of point location after translating global coordinate system origin to point XO
XX	X,Y, and Z components of point location in global coordinate system
YCL	This defines the cylinder-centered reference coordinate system y axis in global reference system components

ZCL	This defines the cylinder-centered reference coordinate system z axis in global reference system components

5. I/O VARIABLES:

A. INPUT	LOCATION
XCL	/ROTRDT/
XO	F.P.
XX	F.P.
YCL	/ROTRDT/
ZCL	/ROTRDT/

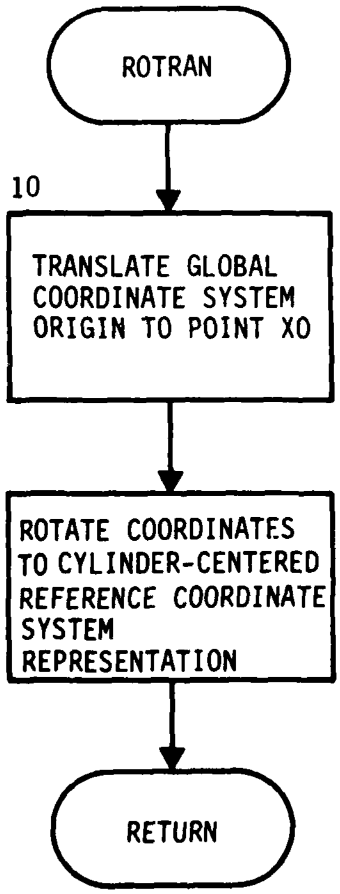
B. OUTPUT	LOCATION
XRT	F.P.

6. CALLING ROUTINE:

GTDDRV

7. CALLED ROUTINE:

NONE


ROTRAN
10
TRANSLATE GLOBAL COORDINATE SYSTEM ORIGIN TO POINT XO
ROTATE COORDINATES TO CYLINDER-CENTERED REFERENCE COORDINATE SYSTEM REPRESENTATION
RETURN

1. NAME: RPLDPL (GTD)

2. PURPOSE: To calculate the unobstructed electric field for a unit source ray that is reflected off plate MR and diffracted by edge ME on plate MP into a given far-field observation direction or to a given near-field observation point.

3. METHOD: RPLDPL is the driver routine to compute the plate-reflected and then edge-diffracted fields. Pertinent geometry is shown in figure 1 and computation details are given in references A-C. The fields are first initialized to zero. Then the diffraction point on edge ME of plate MP is found for the given observation direction or point based on the location of the source imaged through plate MR. The diffraction point is computed in subroutine DFPTWD. If diffraction did not occur, debug information (if requested) is printed on file LUWRNT and control is returned to the calling routine. If diffraction did occur on the vector tangent to the edge, the point location is checked to see if it is between the corners. If it is not, the diffraction point is set at the closest corner and a flag, LDIF, is set to indicate only corner-diffracted fields exist.

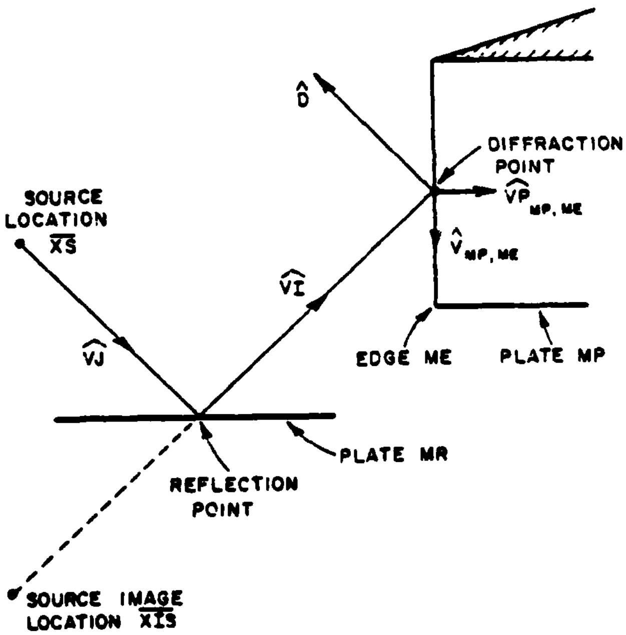


Figure 1. Illustration of a Ray Reflected by a Plate and Then Diffracted by a Plate Edge

Now the ray path is checked for any obstructions. If the path is shadowed, debug information (if requested) is printed and control returns to the calling routine. If the path is clear the field computations begin.

First, necessary diffraction angles and geometry are calculated. Then the source field pattern factor is found by calling subroutine SOURCE and is multiplied by the reflection coefficient. Then the incident field perpendicular and parallel to the edge can be computed.

If slope diffraction is requested, the incident slope field pattern factor is computed by calling subroutine SOURCP. This factor also must be multiplied by the reflection coefficient to account for axis direction changes due to single reflection.

The phase term is now computed. The edge diffraction coefficient is determined in subroutine DW. Now the edge-diffracted fields are computed, first in terms of a parallel and perpendicular orientation and then in theta and phi components. By calling subroutine XYZFLD the x, y, z components of the edge-diffracted field are computed and accumulated with all other fields computed by other reflection and diffraction interactions.

If corner diffraction was requested, the far-field corner-diffracted fields are computed for each corner on edge ME in the same manner as for the edge diffraction.

After all fields have been computed and the x, y, z components accumulated, debug information (if requested) is printed on file LUPRNT. This consists of the field magnitude and theta and phi components of the total field. Control is then returned to the calling routine.

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
ADN	Dot product of vector from plate MP to the source image and the plate unit normal
AFN	Wedge angle number
BETN	Difference in diffracted and incident phi angles
BETP	Sum of diffracted and incident phi angles
BO	Diffracted field beta polarization unit vector in diffraction edge-fixed coordinate system (in x,y,z RCS components)
BOP	Incident field beta polarization unit vector in diffraction edge-fixed coordinate system (in x,y,z RCS components)

BRD	Lower and upper limit for edge diffraction angle
CNP	Cosine of half wedge angle
CORN	Corner diffraction coefficient
CPH	Cosine of PSR
CPHJ	Cosine of PHJR
CPHO	Cosine of PSOR
CTH	Cosine of THR
CTHJ	Cosine of THJR
CTHP	Cosine of THPR
DEL	Parameter used in transition function
DH	Diffraction coefficient for hard boundary condition
DHIR	Distance from reflection point to diffraction point
DHIT	Distance from source to reflection point (from PLAINT)
DHT	Distance from source to hit point (from PLAINT and CYLINT)
DIN	Edge diffraction coefficient (from subroutine DICOEF) for incident diffracted field
DIP	Edge diffraction coefficient (from subroutine DICOEF) for reflected diffracted field
DPH	Slope diffraction coefficient for hard boundary condition
DPS	Slope diffraction coefficient for soft boundary condition
DS	Diffraction coefficient for soft boundary condition

DV	Dot product of edge unit vector and diffracted ray propagation direction unit vector
ECPH	Phi component of corner-diffracted E-field
ECTH	Theta component of corner-diffracted E-field
EDPH	Phi component of edge-diffracted E-field
EDPL	Component of diffracted field parallel to the edge
EDPR	Component of diffracted field perpendicular to the edge
EDTH	Theta component of edge-diffracted E-field
EF	Theta component of corner-diffracted E-field in RCS
EG	Phi component of corner-diffracted E-field in RCS
EIPL	Component of incident field parallel to the edge
EIPLP	Pattern factor for component of incident slope field parallel to the edge
EIPR	Component of incident field perpendicular to the edge
EIPRP	Pattern factor for component of incident slope field perpendicular to the edge
EIX,EIY,EIZ	Source pattern factor for x,y, and z components of incident E-field
EXPH	Complex phase term
FN	Wedge angle number
FNN	Wedge angle indicator
FNP	Angle exterior to wedge in degrees

GAM	Dot product of the diffracted ray direction and the vector from the origin to the diffraction point
ISN	Sign change variable
J	Index variable
LDIF	Logical variable set true if diffraction point is on edge tangent but not within corners. (The diffraction is set to the closest corner)
LDIFFR	Logical variable set true if edge diffraction exists (from subroutine DFPTWD)
LHIT	Set true if ray hits a plate or cylinder (from PLAINT or CYLINT)
MC	Index variable used to step through corners
ME	Edge on plate MP where diffraction occurs
MEC	Corner at end of edge ME
MP	Plate for which diffraction occurs
MR	Plate where reflection occurs
N	DO loop variable
NI	DO loop variable
NJ	DO loop variable
PD	Dot product of diffraction edge binormal and diffracted ray propagation direction
PH	Diffracted field phi polarization unit vector in diffraction edge-fixed coordinate system (in x,y,z RCS components)
PHIR	Phi component of reflected ray propagation direction in RCS
PHJR	Phi component of incident (source) ray propagation direction

PHO	Incident field phi polarization unit vector in diffraction edge-fixed coordinate system (in x,y,z RCS components)
PHSR	Phi component of ray propagation direction after diffraction in RCS
PP	Negative dot product of diffraction edge binormal and incident ray unit vector
PS	PSR*DPR
PSD	Diffracted ray phi angle in edge-fixed coordinate system
PSO	PSOR*DPR
PSOD	Incident ray phi angle in edge-fixed coordinate system
PSOR	Phi component of incident ray direction in edge-fixed coordinate system
PSR	Phi component of diffracted ray propagation direction in edge-fixed coordinate system
QD	Dot product of diffraction plate normal and diffracted ray propagation direction
QI	Negative of dot product of diffracted plate normal and incident ray propagation direction
SBO	Sine of BO, the angle the diffracted ray makes with the edge
SNF	Distance between diffraction point and near-field observation point
SNP	Sine of half wedge angle
SP	Distance from source image to diffraction point (from subroutine DFPTWD)
SPH	Sine of PSR
SPHJ	Sine of PHJR
SPHO	Sine of PSOR

SPP	Distance from source image to modified diffraction point
STHJ	Sine of THJR
STHR	Sine of THR
TERM	Coefficient of corner-diffracted fields
THIR	Theta component of reflected ray direction in RCS
THJR	Theta component of incident (source) ray propagation direction
THPR	Angle diffracted ray makes with edge
THR	Angle between edge unit vector and ray from source image location to corner MC
TPP	Distance parameter used in calculating diffraction coefficients
VAX	3 X 3 matrix defining the source image coordinate system axes
VC	Unit vector from source image to corner 1 or 2 of edge ME
VCM	Distance from source image to corner 1 or 2 of edge ME
VECT	Vector used to move diffraction point off edge for shadowing tests
VI	Unit vector of ray incident on edge from plate reflection (from subroutine DFPTWD)
VIP	Unit vector of ray from source image to modified diffraction point
VJ	X,Y, and Z components of source ray propagation direction
VMG	Distance along the edge from first corner of edge to diffraction point
X1	Single reflection source image location

XC	Corner location
XD	Diffraction point (calculated in subroutine DFPTWD) in RCS
XD1	Diffraction point location
XDP	Modified diffraction point used for shadowing tests
XIS	Source image location (for reflection from plate MR)
XS	Source location in RCS
XSS	Single reflection source image location
ZP	Dot product of propagation direction unit vector and vector from diffraction point to corner MC

5. I/O VARIABLES:

A. INPUT	LOCATION
D	/DIR/
DP	/THPHUV/
DPR	/PIS/
DT	/THPHUV/
FLDPT	/NEAR/
FNN	F.P.
LCORNR	/LOGDIF/
LDEBUG	/TEST/
LNRFLD	/NEAR/
LSLOPE	/LOGDIF/
LSURF	/SURFAC/
LUPRNT	/ADEBUG/

ME	F.P.
MEP	/GEOPLA/
MP	F.P.
MR	F.P.
PHSR	/DIR/
PI	/PIS/
THSR	/DIR/
TPI	/PIS/
V	/GEOPLA/
VMAG	/EDMAG/
VN	/GEOPLA/
VP	/GEOPLA/
VXI	/IMAINF/
X	/GEOPLA/
XI	/IMAINF/
XS	/SORINF/

B. OUTPUT LOCATION

ECPH	F.P.
ECTH	F.P.
EDPH	F.P.
EDTH	F.P.

6. CALLING ROUTINE:

GTDDRV

7. CALLED ROUTINES:

ASSIGN

BEXP

BTAN2

CYLINT

DFPTWD

DICOEF

DW

FFCT

NFD

PLAINT

REFBP

SMAGNF

SOURCE

SOURCP

STATIN

STATOT

TPNFLD

WLKBCK

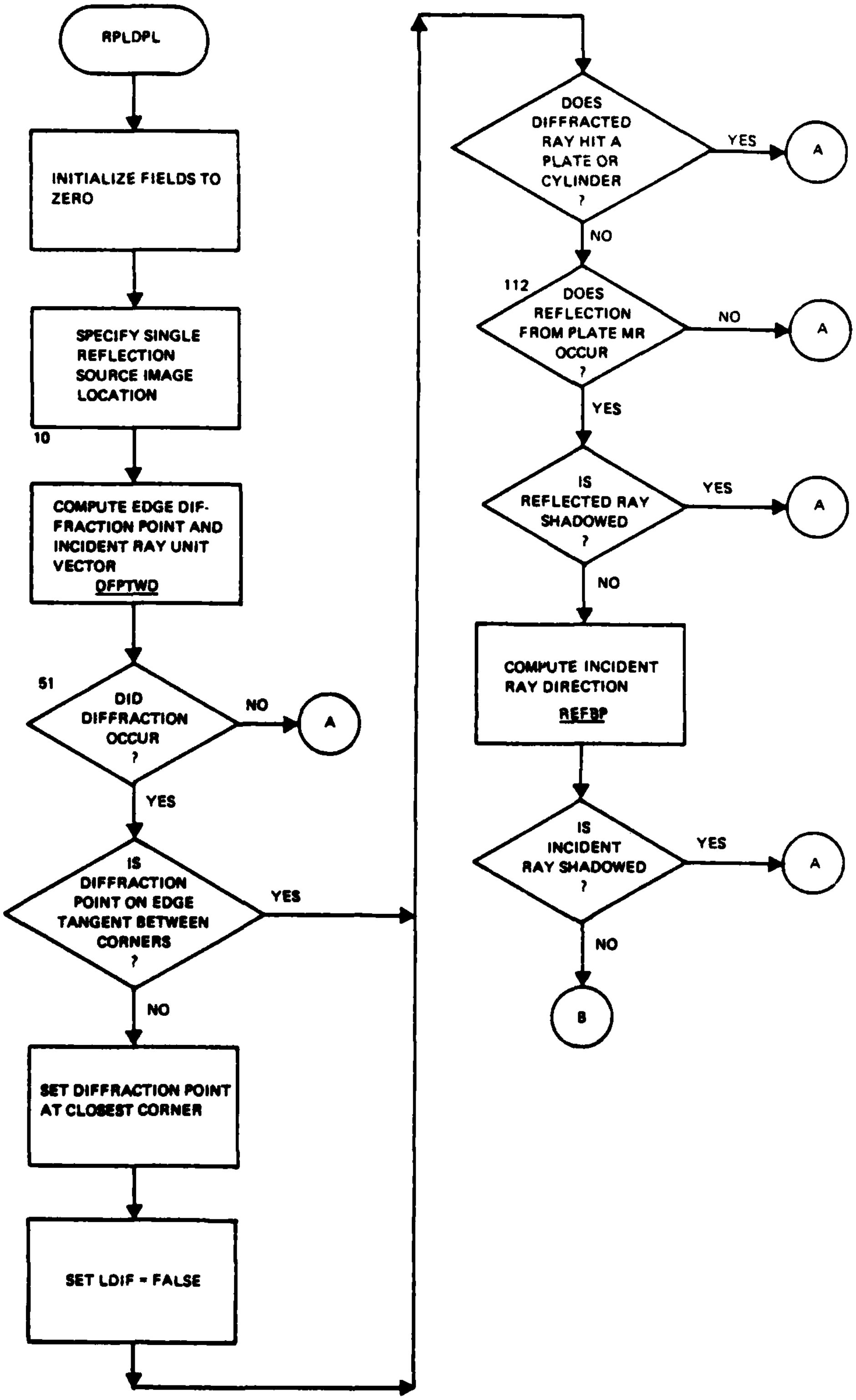
XYZFLD

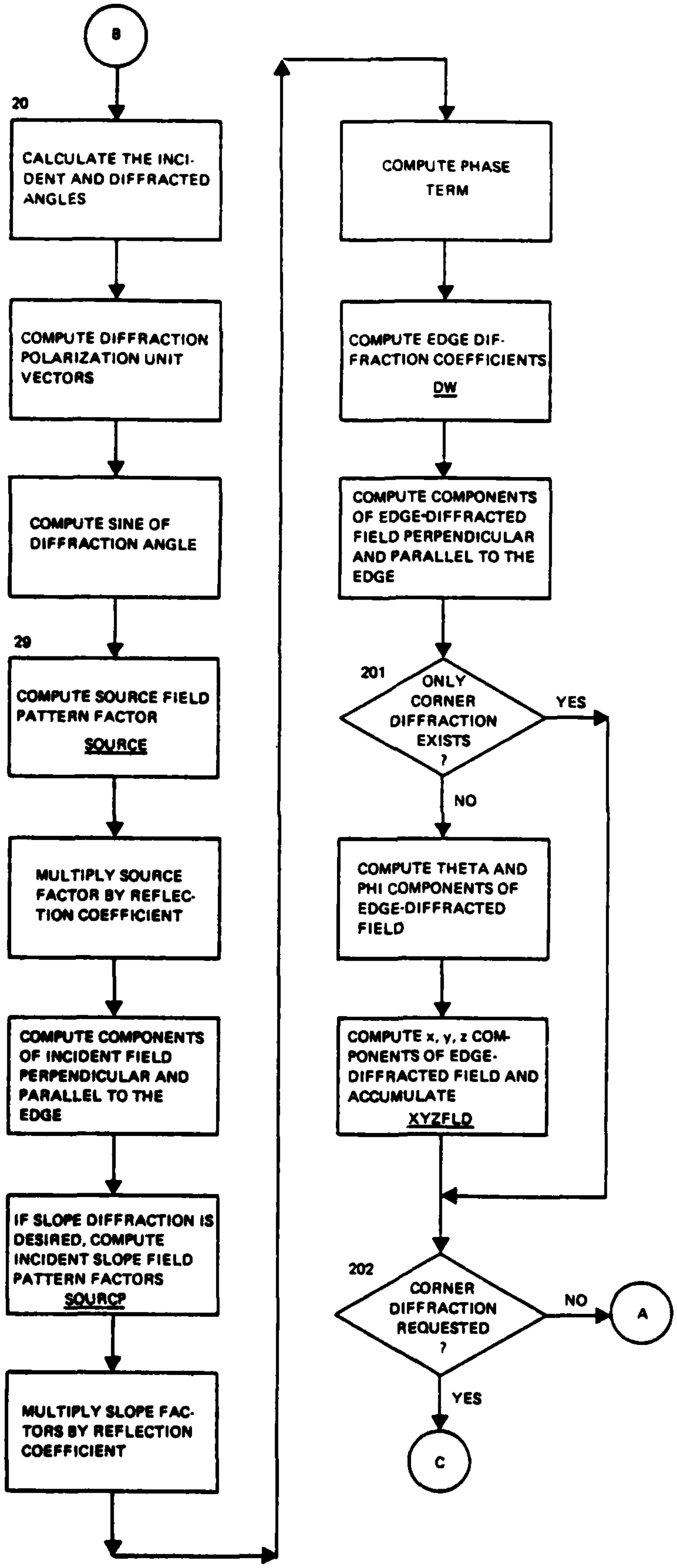
8. REFERENCES:

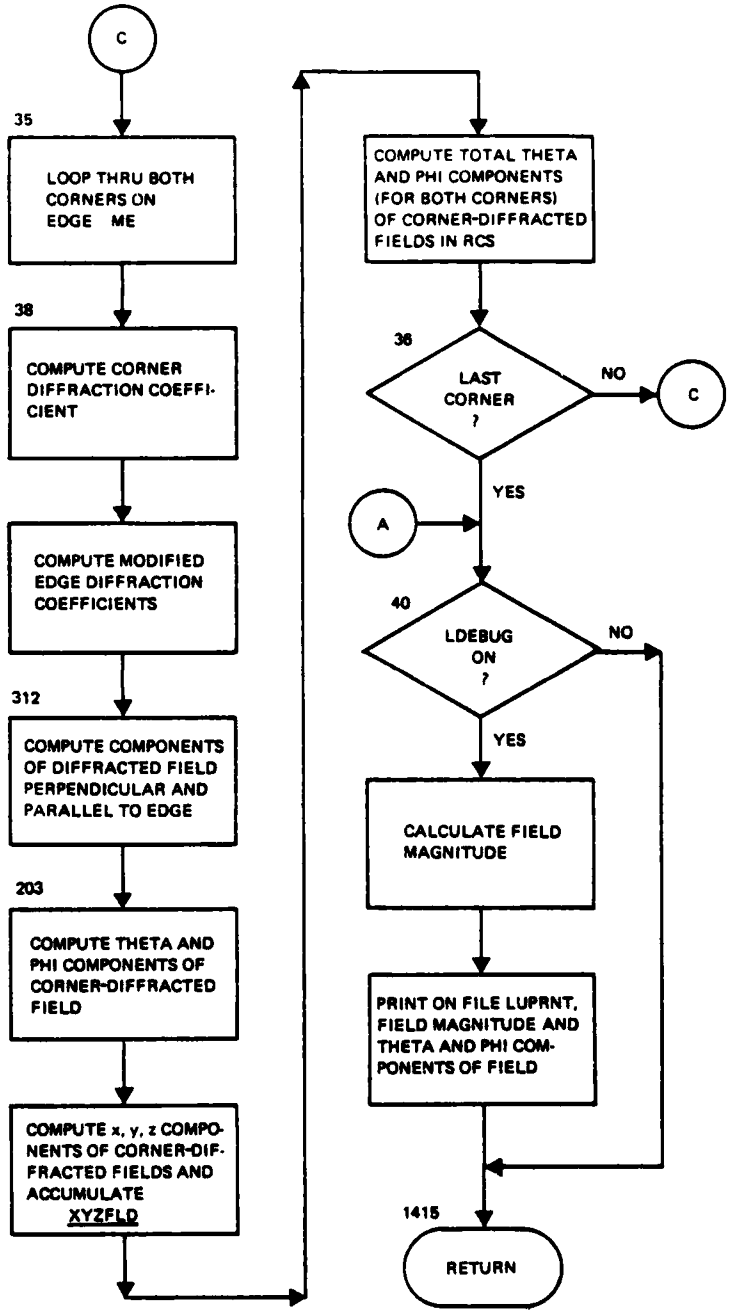
A. R. G. Kouyoumjian and P. H. Pathak, "A Uniform Geometrical Theory of Diffraction for an Edge in a Perfectly Conducting Surface," Proc. IEEE, Vol. 62, November 1974, pp. 1448-1461.

B. W. D. Burnside and P. H. Pathak, "A Corner Diffraction Coefficient," to appear.

C. Y. M. Hwang and R. G. Kouyoumjian, "A Dyadic Diffraction Coefficient for an Electromagnetic Wave Which Is Rapidly Varying at an Edge," USNC-URSI 1974 Annual Meeting, Boulder, CO., Oct. 1974.


RPLDPL
INITIALIZE FIELDS TO ZERO
SPECIFY SINGLE REFLECTION SOURCE IMAGE LOCATION
10
COMPUTE EDGE DIF-FRACTION POINT AND INCIDENT RAY UNIT VECTOR DFPTWD
51
DID DIFFRACTION OCCUR ?
NO
A
YES
IS DIFFRACTION POINT ON EDGE TANGENT BETWEEN CORNERS ?
YES
NO
SET DIFFRACTION POINT AT CLOSEST CORNER
SET LDIF = FALSE
DOES DIFFRACTED RAY HIT A PLATE OR CYLINDER ?
YES
A
NO
112
DOES REFLECTION FROM PLATE MR OCCUR ?
NO
A
YES
IS REFLECTED RAY SHADOWED ?
YES
A
NO
COMPUTE INCIDENT RAY DIRECTION REFBP
IS INCIDENT RAY SHADOWED ?
YES
A
NO
B


B
20
CALCULATE THE INCIDENT AND DIFFRACTED ANGLES
COMPUTE DIFFRACTION POLARIZATION UNIT VECTORS
COMPUTE SINE OF DIFFRACTION ANGLE
29
COMPUTE SOURCE FIELD PATTERN FACTOR
SOURCE
MULTIPLY SOURCE FACTOR BY REFLECTION COEFFICIENT
COMPUTE COMPONENTS OF INCIDENT FIELD PERPENDICULAR AND PARALLEL TO THE EDGE
IF SLOPE DIFFRACTION IS DESIRED, COMPUTE INCIDENT SLOPE FIELD PATTERN FACTORS
SOURCP
MULTIPLY SLOPE FACTORS BY REFLECTION COEFFICIENT
COMPUTE PHASE TERM
COMPUTE EDGE DIFFRACTION COEFFICIENTS
DW
COMPUTE COMPONENTS OF EDGE-DIFFRACTED FIELD PERPENDICULAR AND PARALLEL TO THE EDGE
201
ONLY CORNER DIFFRACTION EXISTS ?
YES
NO
COMPUTE THETA AND PHI COMPONENTS OF EDGE-DIFFRACTED FIELD
COMPUTE x, y, z COMPONENTS OF EDGE-DIFFRACTED FIELD AND ACCUMULATE
XYZFLD
202
CORNER DIFFRACTION REQUESTED ?
NO
A
YES
C


C
35
LOOP THRU BOTH CORNERS ON EDGE ME
38
COMPUTE CORNER DIFFRACTION COEFFI-CIENT
COMPUTE MODIFIED EDGE DIFFRACTION COEFFICIENTS
312
COMPUTE COMPONENTS OF DIFFRACTED FIELD PERPENDICULAR AND PARALLEL TO EDGE
203
COMPUTE THETA AND PHI COMPONENTS OF CORNER-DIFFRACTED FIELD
COMPUTE x, y, z COMPO-NENTS OF CORNER-DIF-FRACTED FIELDS AND ACCUMULATE XYZFLD
COMPUTE TOTAL THETA AND PHI COMPONENTS (FOR BOTH CORNERS) OF CORNER-DIFFRACTED FIELDS IN RCS
36
LAST CORNER ?
NO
C
YES
A
40
LDEBUG ON ?
NO
YES
CALCULATE FIELD MAGNITUDE
PRINT ON FILE LUPRNT, FIELD MAGNITUDE AND THETA AND PHI COM-PONENTS OF FIELD
1415
RETURN

1. NAME: RPLRCL (GTD)

2. PURPOSE: To compute the unobstructed electric field from a unit source reflected by plate MP and then reflected by the cylinder into the far-field observation direction or to the near-field observation point.

3. METHOD: RPLRCL functions as a service routine for subroutine RPLSCL, where the actual plate-cylinder fields are computed. The geometrical optics reflected field components ETH and EPH computed in RPLRCL are used only for reference purposes. The field components calculated in RPLRCL, which are used in RPLSCL, are the hard and soft components of the plate-reflected field incident on the cylinder at the reflection point. These components, along with several other useful parameters, are passed to subroutine RPLSCL through common block FUDGI. Pertinent geometry is shown in figure 1.

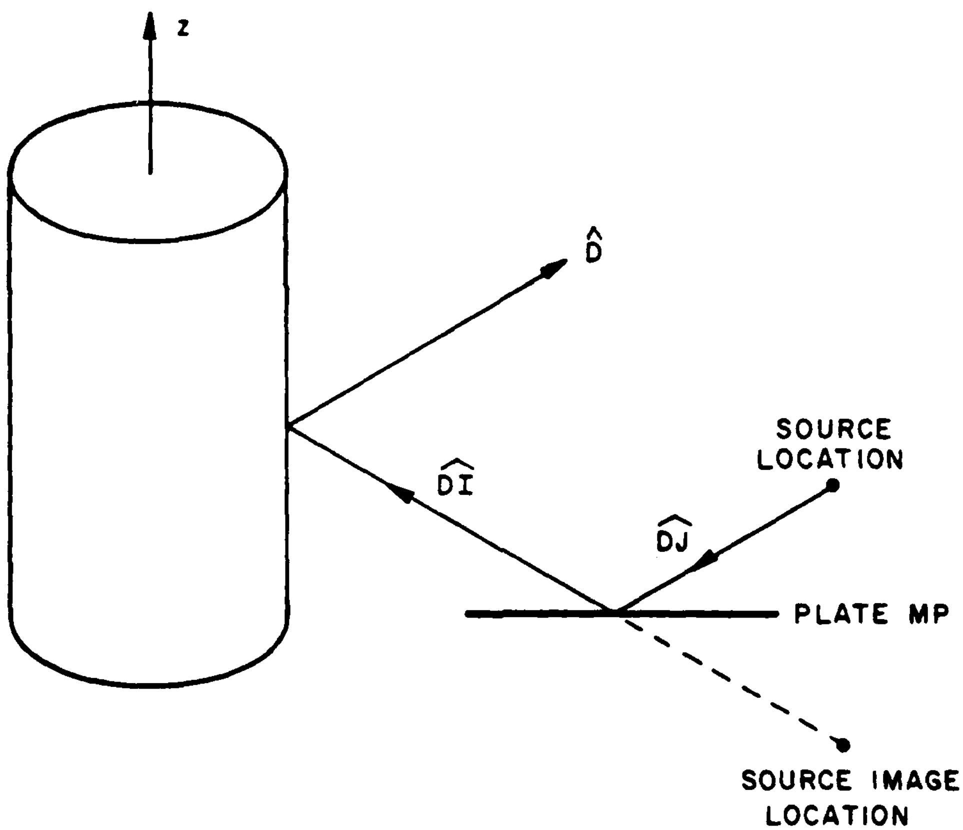


Figure 1. Illustration of Plate-Reflected, Cylinder-Reflected Ray

The code first makes two checks to determine if it is possible for reflection to occur off the cylinder. One check determines if the observation direction or point is in the lit or dark geometrical optic region of the cylinder. The other check is to determine if the observation direction or point is in the paraxial region beyond the end caps. If reflection cannot occur, a flag is set to indicate starting data are not available for the next time subroutine RPLRCL is called. Another flag is also set to indicate the field does not exist. The fields are set to zero and control is returned to the calling routine.

If cylinder reflection could occur, the reflection point is determined by calling subroutine RFDFIN for near-field calculations and subroutine RFPTCL for far-field calculations. The code then checks to see if the cylinder reflection point is beyond the cylinder end caps. If it is, a flag is set to indicate that the geometrical optics field does not exist. The fields are set to zero and control is returned to the calling routine. If the reflection point is on the curved surface of the cylinder, the ray path from the cylinder reflection point in the far-field observation direction or to the near-field observation point is checked for obstructions. Then, the code checks to see if reflection occurs from plate MP. Next, the remainder of the complete ray path is checked for obstructions. If at any point the ray path is shadowed or reflection does not occur from plate MP, the code sets a flag to indicate that the geometrical optics field does not exist. Those fields are set to zero and control is returned to the calling routine.

If the plate and cylinder reflections do occur, and the ray path is not obstructed, the field computations can begin. First, the source field pattern factor is found by calling subroutine SOURCE. The source factor is then multiplied by the reflection coefficient. Next, the polarization unit vectors perpendicular and parallel to the plane of incidence are computed. These are used to compute the incident field components parallel and perpendicular to the plane of incidence. The plate-reflected field components parallel and perpendicular to the plane of incidence are then computed. Next, the theta and phi components of the reflected field are computed. The subroutine then ends by computing the theta and phi components of the hard and soft field components incident upon the cylinder.

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
CTHW	Dot product of cylinder normal and reflection propagation direction unit vector
CW	Cosine of WR

D	Propagation direction after cylinder reflection in x, y, z RCS components
D1	Direction unit vector used for determining if cylinder reflection is possible
D2	Direction unit vector used for determining if cylinder reflection is possible
DD	X-Y distance from the z axis to the cylinder reflection point
DD1	Dot product of unit vector of propagation direction and cylinder tangent unit vector through tangent point 1 (2-D)
DD2	Dot product of unit vector of propagation direction and cylinder tangent unit vector through tangent point 2 (2-D)
DHIS	Distance from reflection point on plate to reflection point on the cylinder
DHIT	Distance from source to hit point (from PLAINT)
DHT	Distance to hit point (from subroutine PLAINT)
DICOEF	X,Y, and Z components of incident ray direction on cylinder in RCS
DOTP	Variable used to indicate if reflection occurred and satisfied Snell's Law
DJ	X,Y,Z components of propagation direction of ray incident on plate
DXY	Dot product of vector from origin to source image location and propagation direction (2-D)
EF	Pattern factor of theta component of incident field in RCS
EG	Pattern factor of phi component of incident field in RCS

EHPHI	Phi component of the hard component of field incident on cylinder (parallel to plane of incidence)
EHTHI	Theta component of the hard component of field incident on cylinder (parallel to plane of incidence)
EIPP	Incident cylinder field component parallel to plane of incidence
EIPR	Incident cylinder field component perpendicular to plane of incidence
EPH	Phi component of cylinder-reflected E-field
ERPP	Cylinder-reflected field component parallel to plane of incidence
ERPR	Cylinder-reflected field component perpendicular to plane of incidence
ERX,ERY,ERZ	X,Y,Z components of field incident on (or reflected from) cylinder in RCS
ESPHI	Phi component of the soft component of field incident on cylinder (perpendicular to plane of incidence)
ESTHI	Theta component of the soft component of field incident on cylinder (perpendicular to plane of incidence)
ETH	Theta component of cylinder-reflected E-field
EX,EY,EZ	Pattern factor of x,y,z components of source field incident on cylinder in RCS
FPTXY	Location of field point in z=0, x-y plane
LHIT	Set true if ray hits plate (from PLAINT)
LRFI	Set true if reflection data are available from previous pattern angle (or for next pattern angle (when leaving routine))

LTRFI	Set true if geometrical optics reflected-reflected field does not exist
MP	Plate on which reflection occurs
ORIGIN	The origin of the reference coordinate system (RCS) (0., 0., 0.)
PH	Complex phase and ray spreading coefficient
PHIR	Phi component of incident ray direction on cylinder
PHJR	Phi angle for direction of ray incident on plate
PHSR1	Phi angle of D1
PHSR2	Phi angle of D2
RHO1I	Ray spreading radius in plane of cylinder curvature at reflection point
RHO2	Ray spreading radius normal to plane of incidence at reflection point
S	Distance from source image to cylinder reflection point
SMAGI	Length of ray from reflection point on cylinder to source image
SNF	Distance between field point and cylinder reflection point
SQRH	Part of spr:ading factor
SXN,SYN,SZN	X,Y, and Z components of unit vector of ray from reflection point on cylinder to source image location in RCS
THIR	Theta component of incident ray direction on cylinder
THJR	Theta angle which defines direction of ray incident on plate
THSR1	Theta angle of D1

THSR2	Theta angle of D2
UB	Unit vector of binormal to cylinder at reflection point (2-D)
UN	Unit vector of normal to cylinder at reflection point (2-D)
UIPPX,UIPPY,UIPPZ	X,Y,Z components of incident field polarization unit vector parallel to plane of incidence
UIPRX,UIPRY,UIPRZ	X,Y,Z components of incident reflected field polarization unit vector perpendicular to plane of incidence
URPPX,URPPY,URPPZ	X,Y,Z components of reflected field polarization unit vector parallel to plane of incidence
VAX	Matrix defining source coordinate system axes in RCS components
VR	Phi angle at which cylinder reflection occurs
XE1	Vector in the direction of the more positive end cap used to determine if cylinder reflection can occur
XE2	Vector in the direction of the more negative end cap used to determine if cylinder reflection can occur
XIS	X,Y,Z components of source image location also reflection point on plate
XPI	Location of reflection point on cylinder in x,y,z RCS
XSS	Source image location
XT1	Cylinder tangent point one location in x-y plane of vector from source image
XT2	Cylinder tangent point two location in x-y plane of vector from source image

5. I/O VARIABLES:

A. INPUT

INPUT	LOCATION
A	/GEOMEL/
B	/GEOMEL/
BTI	/BNDICL/
CPS	/DIR/
CTC	/GEOMEL/
CTHS	/DIR/
D	/DIR/
DP	/THPHUV/
DT	/THPHUV/
DTI	/BNDICL/
FLDPT	/NEAR/
LDEBUG	/TEST/
LNRFLD	/NEAR/
LRFI	/CLRFI/
LUPRNT	/ADEBUG/
MP	F. P.
PHSR	/DIR/
PI	/PIS/
SPS	/DIR/
STHS	/DIR/
THSR	/DIR/
TPI	/PIS/
VTI	/BNDICL/

	VXI	/IMAINF/
	XI	/IMAINF/
	XS	/SORINF/
	ZC	/GEOMEL/
B.	OUTPUT	LOCATION
	CPS	/DIR/
	EHPHI	/FUDGI/
	EHTHI	/FUDGI/
	EPH	F. P.
	ESPHI	/FUDGI/
	ESTHI	/FUDGI/
	ETH	F. P.
	LRFI	/CLRFI/
	LTRFI	/FUDGI/
	RGII	/FUDGI/
	RHO1I	/FUDGI/
	SMAGI	/FUDGI/
	SPS	/DIR/
	TRANI	/FUDGI/
	XRI	/FUDGI/

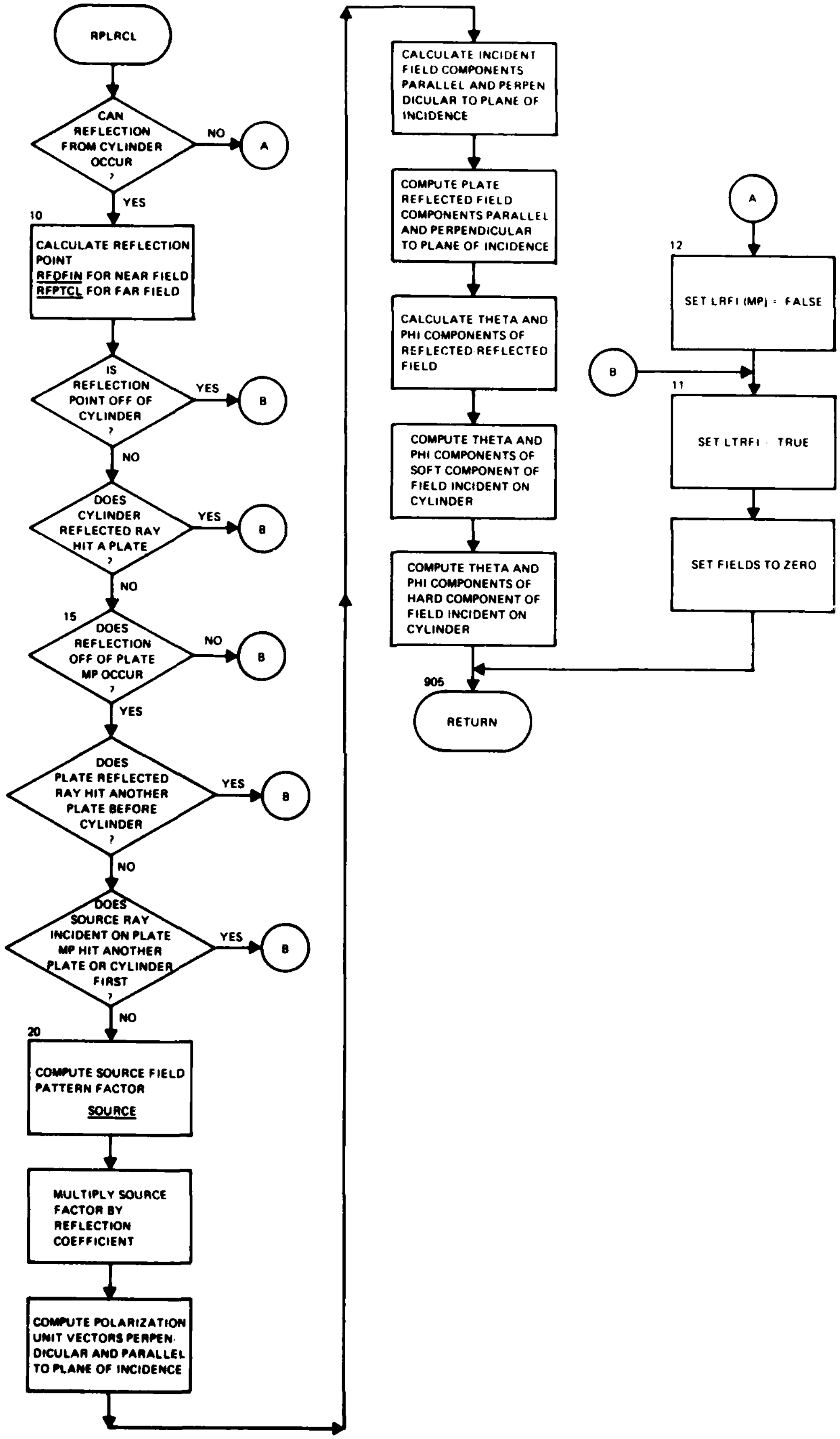
6. CALLING ROUTINE:

RPLSCL

7. CALLED ROUTINES:

ASSIGN	RFDFIN
BEXP	RFPTCL
BTAN2	SMAGNF
CYLINT	SOURCE
NANDB	STATIN
NFD	STATOT
PLAINT	TPNFLD
REFBP	WLKBCK

RPLRCL (GTD)



RPLRCL
CAN REFLECTION FROM CYLINDER OCCUR ?
NO
A
YES
10
CALCULATE REFLECTION POINT
RFDFIN FOR NEAR FIELD
RFPTCL FOR FAR FIELD
IS REFLECTION POINT OFF OF CYLINDER ?
YES
B
NO
DOES CYLINDER REFLECTED RAY HIT A PLATE ?
YES
B
NO
15
DOES REFLECTION OFF OF PLATE MP OCCUR ?
NO
B
YES
DOES PLATE REFLECTED RAY HIT ANOTHER PLATE BEFORE CYLINDER ?
YES
B
NO
DOES SOURCE RAY INCIDENT ON PLATE MP HIT ANOTHER PLATE OR CYLINDER FIRST ?
YES
B
NO
20
COMPUTE SOURCE FIELD PATTERN FACTOR
SOURCE
MULTIPLY SOURCE FACTOR BY REFLECTION COEFFICIENT
COMPUTE POLARIZATION UNIT VECTORS PERPENDICULAR AND PARALLEL TO PLANE OF INCIDENCE
CALCULATE INCIDENT FIELD COMPONENTS PARALLEL AND PERPENDICULAR TO PLANE OF INCIDENCE
COMPUTE PLATE REFLECTED FIELD COMPONENTS PARALLEL AND PERPENDICULAR TO PLANE OF INCIDENCE
CALCULATE THETA AND PHI COMPONENTS OF REFLECTED REFLECTED FIELD
COMPUTE THETA AND PHI COMPONENTS OF SOFT COMPONENT OF FIELD INCIDENT ON CYLINDER
COMPUTE THETA AND PHI COMPONENTS OF HARD COMPONENT OF FIELD INCIDENT ON CYLINDER
905
RETURN
A
12
SET LRFI (MP) = FALSE
B
11
SET LTRFI = TRUE
SET FIELDS TO ZERO

1. NAME: RPLRPL (GTD)

2. PURPOSE: To compute the unobstructed electric field from a unit source due to double reflection from specified plates (reflection off plate MP and then plate MPP).

3. METHOD: RPLRPL is the driver routine which directs the ray tracing, physics and field calculations for double reflection off specified plates in a given far-field direction or to a near-field observation point from a unit source. The pertinent geometry is shown in figure 1.

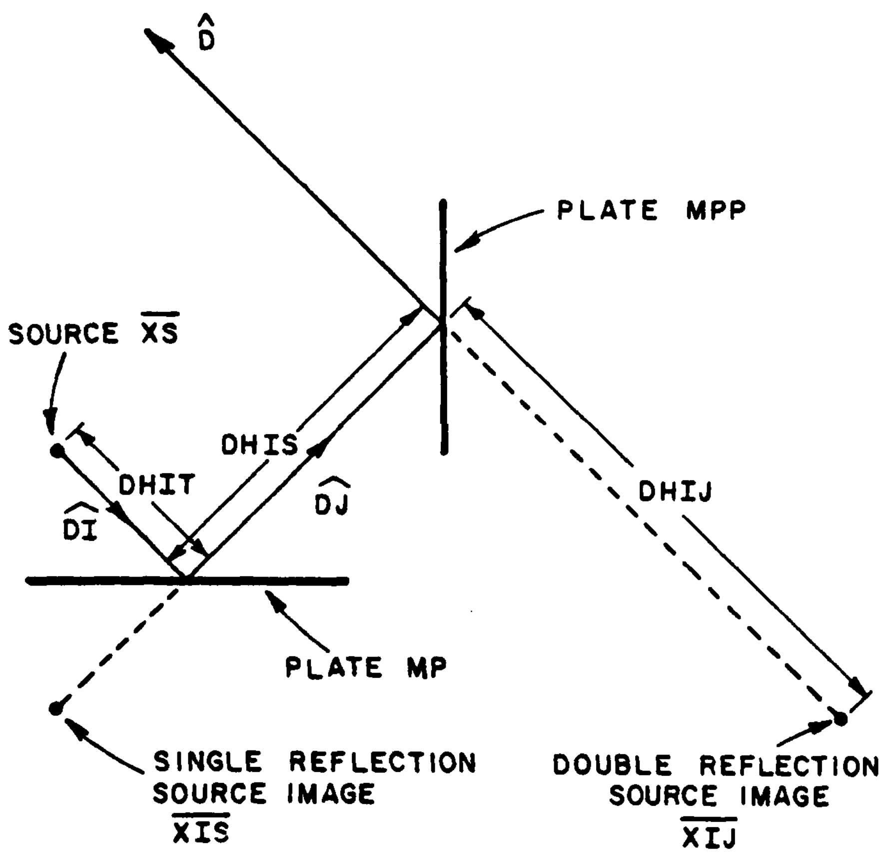


Figure 1. Geometry for Double Reflected Ray

First the ray path from the double reflection source image is checked to see if it passes through plate MPP. If it does, the ray path from the reflection point on plate MPP in the desired far-field

direction or to the near-field observation point is checked for obstructions. If this ray did not hit another plate or a cylinder, the rays between the first and second reflection points and between the source and first reflection point are also checked to see if they are blocked. If none of these separate paths is blocked, then it is known that reflections on the two plates specified did occur in the correct order and that the complete ray path is unobstructed. If at any check the ray was blocked by another plate or a cylinder, or the ray did not pass through plates MP and MPP as required for double reflection, the code immediately sets the theta and phi components of the electric field to zero, and no other computations except debug functions (if requested) are performed in this routine.

If the ray path is unobstructed and the reflections occurred, the source field pattern factor at the double reflection source image location is computed in subroutine SOURCE. The phase factor is then computed. For far field this will refer the electric field back to the origin of the reference coordinate system (RCS). For near field the phase factor includes the spherical wave spread factor. Now the theta and phi components of the electric field are computed. The electric field is given as:

$$\bar{E} = (\underbrace{EF\,\hat{\theta}} + \underbrace{EG\,\hat{\phi}})\,\underbrace{e^{j2\pi(\overline{XIJ}\cdot\hat{D})}}, \text{ for far field}$$

from subroutine SOURCE - theta component of source factor	from sub-routine SOURCE - phi component of source factor	EX - phase factor

and

$$\bar{E} = (\underbrace{EF\,\hat{\theta}} + \underbrace{EG\,\hat{\phi}})\,\underbrace{\frac{e^{-j2\pi SNF}}{SNF}}, \text{ for near field.}$$

from subroutine SOURCE - theta component of source factor	from subroutine SOURCE - phi component of source factor	EX - phase factor where SNF = $|\overline{FLDPT} - \overline{XIJ}|$

The x, y, z components of the electric field are computed and accumulated by calling subroutine XYZFLD.

If the debug capabilities have been requested, the doubly reflected field magnitude is computed. The magnitude, theta and phi complex components of the field are printed on file LUPRNT.

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
CPHI	Cosine of PHIR
CPHJ	Cosine of PHJR
CTHI	Cosine of THIR
CTHJ	Cosine of THJR
D	X,Y,Z components of ray propagation direction after second reflection in RCS
DHIJ	Distance from double reflection image to hit point on plate MPP
DHIS	Distance between reflection points
DHIT	Distance from source to reflection point (from PLAINT)
DHT	Distance (calculated in PLAINT or CYLINT) from source or point from which ray originates to hit point
DICOEF	X,Y,Z components of incident ray propagation direction in RCS
DJ	X,Y,Z components of propagation direction of ray incident on plate MPP
EF	Theta component of source field pattern factor
EG	Phi component of source field pattern factor
EIX,EIY,EIZ	X,Y,Z components of source field pattern factor

ERP	Phi component of electric field
ERT	Theta component of electric field
EX	Complex phase factor
FLDMAG	The electric field magnitude
FLDPT	The x,y,z location of the near-field observation point
GAM	Phase distance to origin (dot product of double reflection image location and reflected ray propagation direction)
LDEBUG	Logical variable set true if debug option requested
LHIT	Set true if ray intersects a plate or cylinder (from PLAINT or CYLINT)
LNRFLD	Flag to indicate if far-field (LNRFLD=0) or near-field (LNRFLD=1) calculations are requested
MP	Plate from which first reflection occurs
MPP	Plate from which second reflection occurs
PHIR	Phi angle of incident ray propagation direction in RCS
PHJR	Phi angle of ray direction between reflections in RCS
PHSR	Phi angle of ray propagation direction after reflection in RCS
SNF	Distance from double reflection image location to observation field point
SPHI	Sine of PHIR
SPHJ	Sine of PHJR
STHI	Sine of THIR
STHJ	Sine of THJR

THIR	Theta angle of incident ray propagation direction in RCS
THJR	Theta angle of ray direction between reflections in RCS
THSR	Theta angle of ray propagation direction after reflections in RCS
VAX	X,Y,Z components defining unit vectors of the source image coordinate system axes in RCS components
VAXP	X,Y,Z components defining unit vectors of the source image coordinate system axes in RCS for double reflection
XI	Triply dimensioned array of image locations
XIJ	X,Y,Z components of double reflection image location
XIS	X,Y,Z components of single reflection source image location (single reflection from plate MP)
XQ	X,Y,Z components of double reflection image location
XS	Source location in x,y,z RCS

5. I/O VARIABLES:

A. INPUT

INPUT	LOCATION
D	/DIR/
FLDPT	/NEAR/
LDEBUG	/TEST/
LNRFLD	/NEAR/
LUPRNT	/ADEBUG/
MP	F.P.
MPP	F.P.

PHSR	/DIR/
THSR	/DIR/
TPI	/PIS/
VXI	/IMAINF/
XI	/IMAINF/
XS	/SORINF/
B. OUTPUT	LOCATION
ERP	F.P.
ERT	F.P.

6. CALLING ROUTINE:

GTDDRV

7. CALLED ROUTINES:

ASSIGN

BEXP

CYLINT

IMDIR

NFD

PLAINT

REFBP

SMAGNF

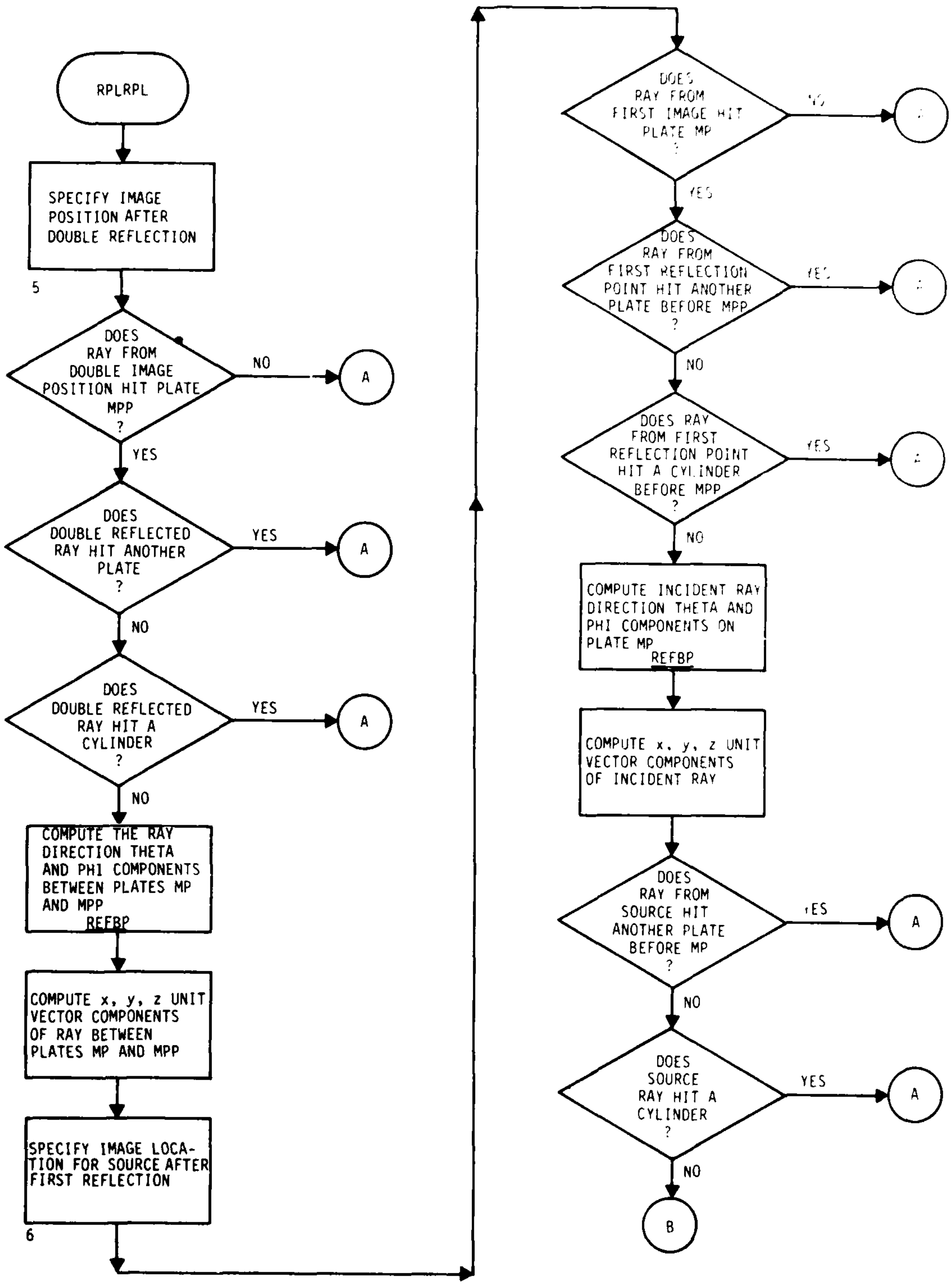
SOURCE

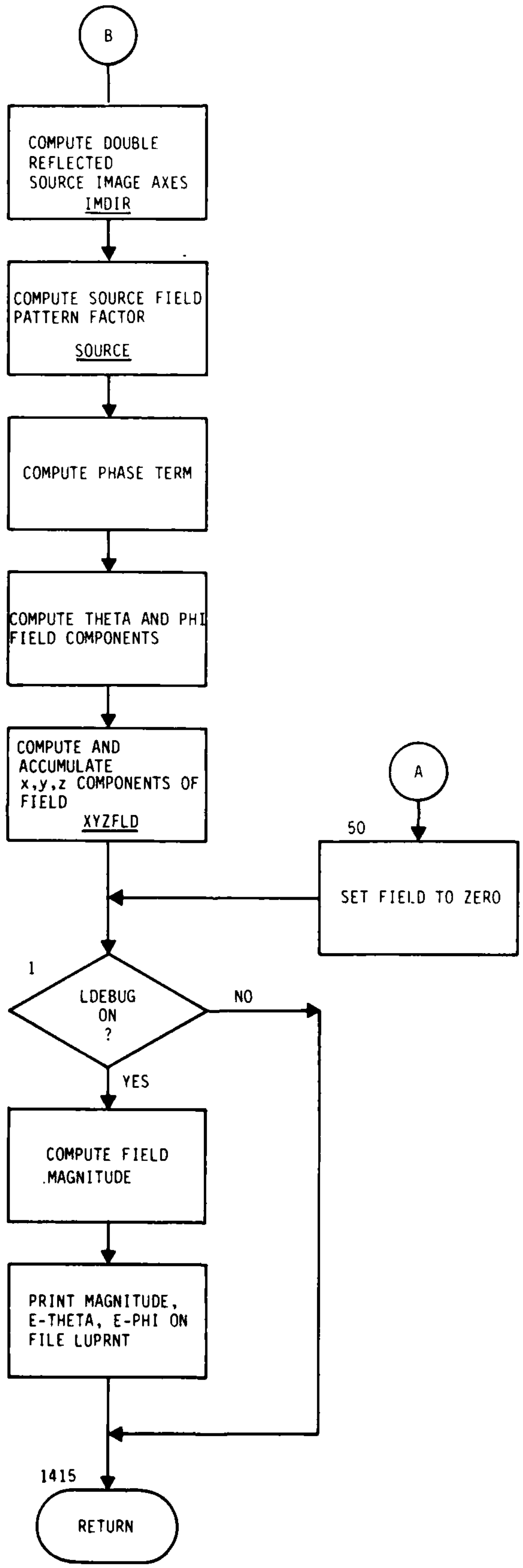
STATIN

STATOT

WLKBCK

XYZFLD


RPLRPL
SPECIFY IMAGE POSITION AFTER DOUBLE REFLECTION
5
DOES RAY FROM DOUBLE IMAGE POSITION HIT PLATE MPP ?
NO
A
YES
DOES DOUBLE REFLECTED RAY HIT ANOTHER PLATE ?
YES
A
NO
DOES DOUBLE REFLECTED RAY HIT A CYLINDER ?
YES
A
NO
COMPUTE THE RAY DIRECTION THETA AND PHI COMPONENTS BETWEEN PLATES MP AND MPP
REFBP
COMPUTE x, y, z UNIT VECTOR COMPONENTS OF RAY BETWEEN PLATES MP AND MPP
SPECIFY IMAGE LOCATION FOR SOURCE AFTER FIRST REFLECTION
6
DOES RAY FROM FIRST IMAGE HIT PLATE MP ?
YES
DOES RAY FROM FIRST REFLECTION POINT HIT ANOTHER PLATE BEFORE MPP ?
NO
DOES RAY FROM FIRST REFLECTION POINT HIT A CYLINDER BEFORE MPP ?
NO
COMPUTE INCIDENT RAY DIRECTION THETA AND PHI COMPONENTS ON PLATE MP
REFBP
COMPUTE x, y, z UNIT VECTOR COMPONENTS OF INCIDENT RAY
DOES RAY FROM SOURCE HIT ANOTHER PLATE BEFORE MP ?
A
NO
DOES SOURCE RAY HIT A CYLINDER ?
YES
A
NO
B


B
COMPUTE DOUBLE REFLECTED SOURCE IMAGE AXES
IMDIR
COMPUTE SOURCE FIELD PATTERN FACTOR
SOURCE
COMPUTE PHASE TERM
COMPUTE THETA AND PHI FIELD COMPONENTS
COMPUTE AND ACCUMULATE x,y,z COMPONENTS OF FIELD
XYZFLD
A
50
SET FIELD TO ZERO
1
LDEBUG ON ?
NO
YES
COMPUTE FIELD MAGNITUDE
PRINT MAGNITUDE, E-THETA, E-PHI ON FILE LUPRNT
1415
RETURN

1. NAME: RPLSCL (GTD)

2. PURPOSE: To compute the unobstructed electric field from a unit source reflected by plate MP and then scattered by the cylinder in the given far-field observation direction or to a given near-field observation point.

3. METHOD: RPLSCL is the driver routine which directs all the ray tracing, physics and field calculations for determining the electric field reflected by a plate and then scattered by the cylinder in the given far-field observation direction or to a given near-field observation point. The geometry is shown in figure 1.

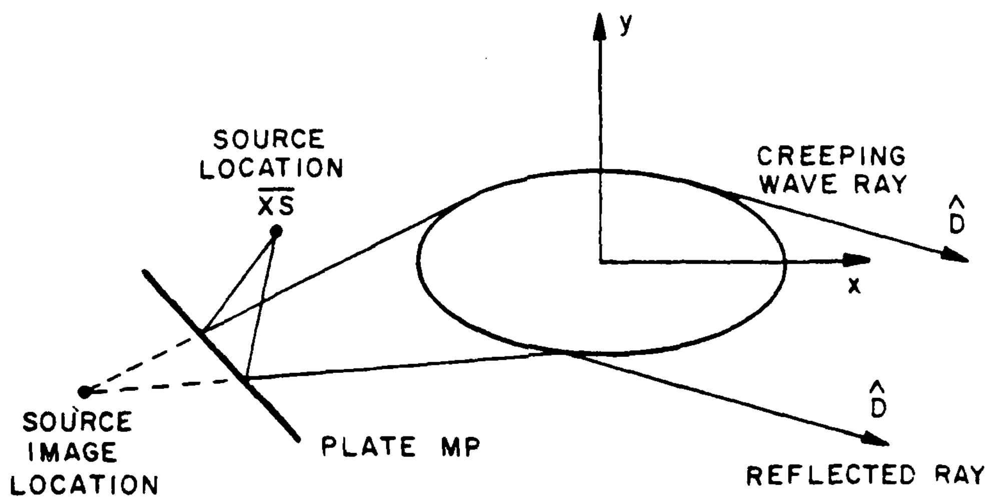


Figure 1. Illustration of Ray Reflected by a Plate and Then Scattered by the Clyinder

The code begins by initializing the fields to zero. The code then makes a check to see if the plate-reflected rays can illuminate the cylinder curved surface. If they cannot, debug information (if requested) is printed on file LUPRNT. Control is then returned to the calling routine. If the plate-reflected rays can illuminate the curved surface of the cylinder, the code steps through the tangent vectors to calculate fields based on a value ALR. ALR is the reflected ray phi angle in the tangent point coordinate system. The tangents are found from the image of the source through plate MP tangent to the cylinder curved surface. If ALR is less than π, a plate-reflected cylinder-reflected ray can be determined. If ALR is greater tha. π, a creeping wave exists for this tangent on the

cylinder. If ALR is approximately π, grazing incidence occurs on the cylinder. After the fields associated with one tangent have been found, the code proceeds to the next tangent and calculates the new value of ALR. The fields associated with this tangent are then determined. All the fields are accumulated in subroutine XYZFLD in common block FLDXYZ. After the total field is found, debug information (if requested) is printed on file LUPRNT. The debug information consists of field magnitude, theta and phi components of the total field. Control is then returned to the calling routine.

If ALR is less than π, a reflected ray path will possibly be found on the cylinder. Subroutine RPLRCL calculates the ray path for a plate-reflected ray followed by a cylinder-reflected ray. It also calculates parameters associated with this ray path and field. These parameters and the field incident upon the cylinder are passed to subroutine RPLSCL through common block FUDGI. Once control is returned to RPLSCL, this subroutine checks to make sure reflected fields are present. If they are not, the code will proceed to the next tangent. If reflected fields are present, the code checks to see if reflection should be handled by the second tangent. If it should, the tangent index is set for the second tangent. Field computations can now begin. The hard and soft components of the field incident on the cylinder, obtained from common block FUDGI, are converted into the cylinder-reflected field. This is the total plate-reflected cylinder-reflected field. The x, y, z components of this field are computed in subroutine XYZFLD. The field is also accumulated in this subroutine with fields from other interactions.

If ALR is greater than π, a creeping wave can occur along the cylinder. The code to determine the incident point and the point at which the creeping wave leaves the cylinder is different for near-field and far-field calculations. Please refer to the accompanying flowchart for the specifics of this procedure. While in the different near-field and far-field paths, the code does compute the same items. The x, y, z components of the point at which the creeping wave leaves the cylinder and the x,y,z components of the point at which the creeping wave begins on the cylinder are computed. These points are checked to make sure that they exist on the curved surface of the cylinder and not beyond the end caps. Also, the code checks to see if reflection from plate MP can occur. The ray path between the reflection and initial diffraction point are checked for shadowing. The ray path from the source to the plate reflection point is checked for shadowing also. While still in the separate near-field/far-field paths, the incident source field pattern factor is computed by calling subroutine SOURCE. The source factor is multiplied by the reflection coefficient. Various other parameters associated with the path lengths needed for phase factors and ray spreading radii are computed. The code comes back together and checks if the cylinder-diffracted ray is obstructed. If not, the

total phase factor is computed, and the hard and soft components of the creeping wave are determined. From this, the total plate-reflected cylinder-diffracted field can be found. It is converted into x,y,z components and accumulated in subroutine XYZFLD.

If ALR is approximately equal to π, grazing incidence can occur on the cylinder. In this section, the code first checks to see if reflection from plate MP can occur. If it can, the ray between the reflection point and the far-field observation direction or near-field observation point is checked for obstructions. Then the source ray is checked for shadowing. If the ray paths are clear, the grazing incident point is computed. This point is checked to make sure it is on the curved surface of the cylinder and not beyond the end caps. If the ray path is legitimate, then the source field pattern factor is computed by calling subroutine SOURCE. The source factor is multiplied by the reflection coefficient. A phase factor is determined. The hard and soft components of the field incident at the grazing point are determined. By combining this field with the grazing incident transition field, the total plate-reflected cylinder-scattered field can be determined. The x,y,z components of the grazing incidence field are computed and accumulated in subroutine XYZFLD.

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
ALR	Cylinder-reflected ray phi angle in tangent point coordinate system (2-D)
ALS	Phi angle defining direction of ray from RCS origin to source image in tangent point coordinate system
BX,BY,BZ	X,Y,Z components of polarization unit vector of soft component of field incident on cylinder (parallel to cylinder surface and normal to incident ray propagation direction)
CCC	Real part of the Fresnel integral
CFH	Hard transition field coefficient
CFS	Soft transition field coefficient
DEPH	Phi component of transition field in RCS
DETH	Theta component of transition field in RCS

DHIT	Distance from source image to plate reflection point (from PLAINT)
DHIV	Distance from plate reflection point to cylinder
DHT	Distance from source to hit point (from PLAINT)
DICOEF	Unit vector of ray incident on cylinder
DIJ	X,Y plane vector from a source image tangent ray to the point the creeping wave leaves the cylinder.
DIJXDJ	Cross product of DIJ and DJT
DIT	Cylinder incident ray vector
DIXDIJ	Cross product of DIT and DIJ
DJ	X,Y,Z components of unit vector of propagation direction of source ray incident on plate
DJT	X-Y plane components of observation direction
DMAG	Distance between plate reflection point and the near-field observation point for grazing incidence calculations
EF	Pattern factor for theta component of incident field in RCS
EG	Pattern factor for phi component of incident field in RCS
EHP	Phi component of hard component of field incident on cylinder in RCS
EHT	Theta component of hard component of field incident on cylinder in RCS
EIX,EIY,EIZ	Pattern factor for x,y,z components of incident field in RCS
EP	Phi component of cylinder-scattered E-field with phase referred to RCS origin

ER	Dot product of unit vector tangent to cylinder and the propagation direction unit vector
ERP	Phi component of field reflected by plate then reflected by cylinder
ERT	Theta component of field reflected by plate then reflected by cylinder
ESP	Phi component of soft component of field incident on cylinder in RCS
EST	Theta component of soft component of field incident on cylinder in RCS
ET	Theta component of cylinder-scattered E-field with phase referred to RCS origin
FPTXY	The x-y plane components of the near-field observation field point
I	Variable used to step through tangent points
LHIT	Set true if ray hits a plate (from PLAINT)
LTRFI	(Returned from RPLRCL) set true if geometrical optics cylinder-reflected field does not exist
LVJ	Logical variable set true first time creeping wave computations begin
MP	Plate where reflection occurs
ORIGIN	RCS origin (0.,0.,0.)
PHIR	Phi component of propagation direction of ray incident on cylinder
PHJR	Phi component of propagation direction of source ray incident on plate
S	Length of vector from source image to tangent point (2 or 3-D). Also, the total distance between the source image point and the cylinder incidence point

S1	X-Y plane distance between the source image and incident point
S2	X-Y plane distance between the field point and the point on the cylinder at which the creeping wave leaves
SNF	Distance between near-field observation point and point at which ray path leaves cylinder (from reflection or creeping wave)
SS	Distance of path along the cylinder
SSS	Imaginary part of the Fresnel integral
STA	Elliptical angle defining the source tangent point x-y location
THIR	Theta component of propagation direction of ray incident on cylinder
THJR	Theta component of propagation direction of source ray incident on plate
UB	Unit binormal at reflection point phi angle (2-D) in x-y plane
UN	Unit normal at reflection point phi angle (2-D) in x-y plane
VAX	Source image axes
VD	Elliptical angle defining point where creeping wave leaves cylinder
VI	Elliptical angle used to define tangent points (2-D)
VJ	Elliptical angles defining the two tangent points on the cylinder for the vector from the field point tangent to the cylinder
VJB	The elliptical angle defining the x-y plane point on the cylinder at which the creeping wave leaves the cylinder
VL	Elliptical angle defining lower range of creeping wave travel on cylinder (2-D)

VU	Elliptical angle defining upper range of creeping wave travel on cylinder (2-D)
XD,YD,ZD	X,Y,Z components of direction of ray from source to cylinder tangent point (incident ray for creeping and grazing incidence cases)
XII,YII,ZII	X,Y,Z components of point where incident creeping wave (or grazing wave) meets cylinder
XIS	X,Y,Z components of image source location (for reflection from plate MP)
XPP	X,Y,Z components of point where ray leaves cylinder
XPT	Incident point on cylinder
XRF	X,Y,Z components of point where creeping wave leaves cylinder
XSS	Source image location through plate MP
XXX	Argument of the Fresnel integral

5. I/O VARIABLES:

A. INPUT

INPUT	LOCATION
A	/GEOMEL/
AS	/GTD/
B	/GEOMEL/
BTI	/BNDICL/
CJ	/COMP/
CPI4	/COMP/
CPS	/DIR/
CTC	/GEOMEL/
CTHS	/DIR/

RPLSCL (GTD)

D	/DIR/
DTI	/BNDICL/
EHPHI	/FUDGI/
EHTHI	/FUDGI/
ESPHI	/FUDGI/
ESTHI	/FUDGI/
FLDPT	/NEAR/
ID	/GTD/
LDEBUG	/TEST/
LNRFLD	/NEAR/
LRFI	/CLRFI/
LTRFI	/FUDGI/
LUPRNT	/ADEBUG/
MP	F.P.
PI	/PIS/
PHSR	/DIR/
RGII	/FUDGI/
RHO1I	/FUDGI/
SAS	/GTD/
SMAGI	/FUDGI/
SPS	/DIR/
STHS	/DIR/
THSR	/DIR/
TPI	/PIS/
TRANI	/FUDGI/
VTI	/BNDICL/

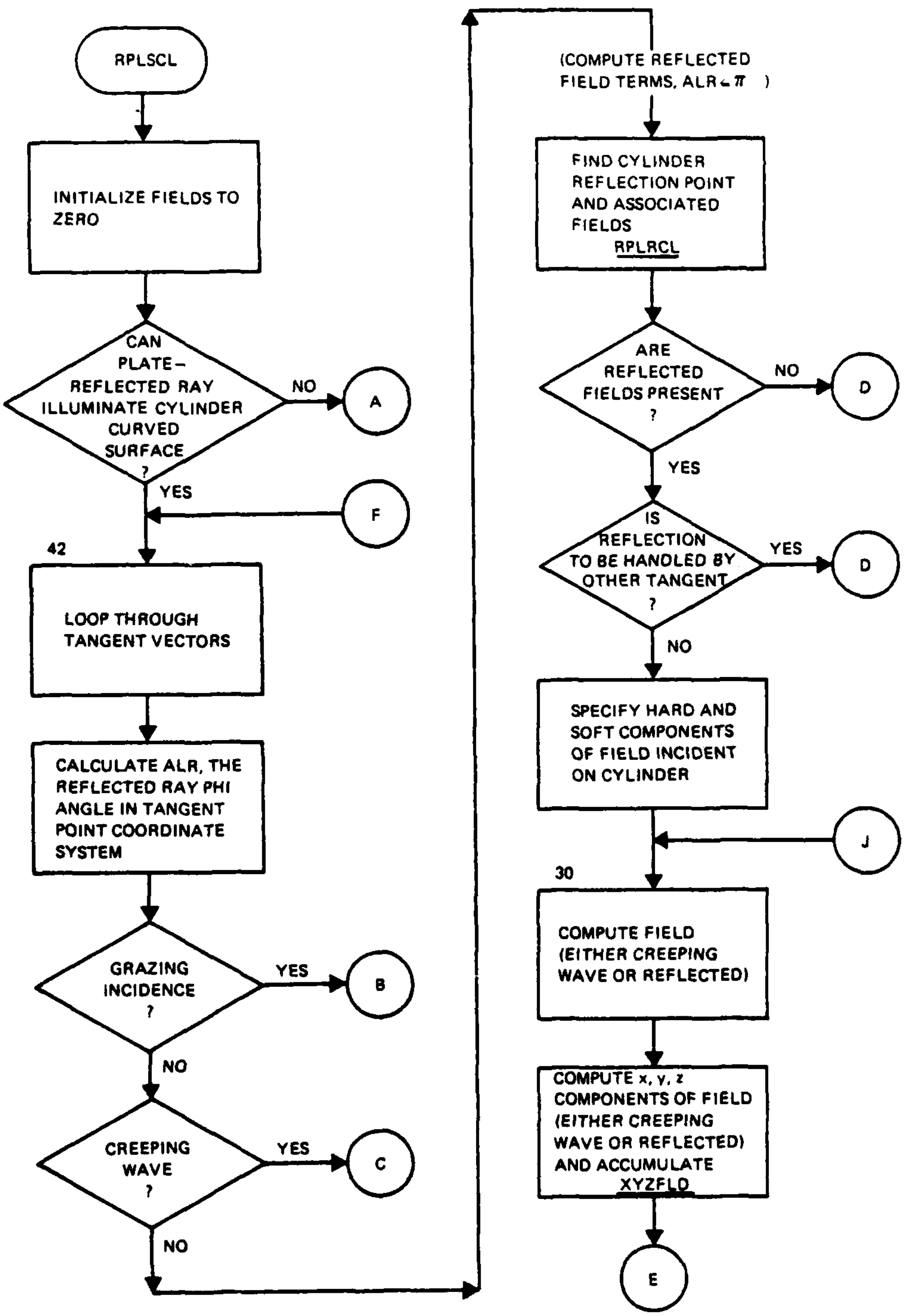
VXI	/IMAINI/
XI	/IMAINI/
XRI	/FUDGI/
XS	/SORINF/
ZC	/GEOMEL/
B. OUTPUT	LOCATION
EP	F.P.
ERP	F.P.
ERT	F.P.
ET	F.P.
LRFI	/CLRFI/

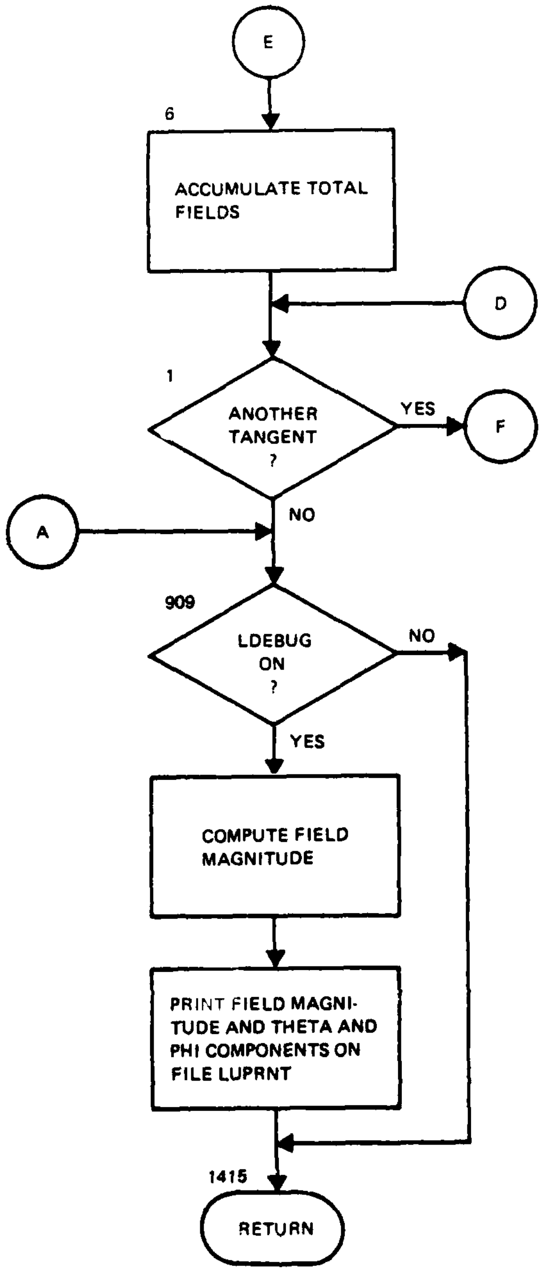
6. CALLING ROUTINE:

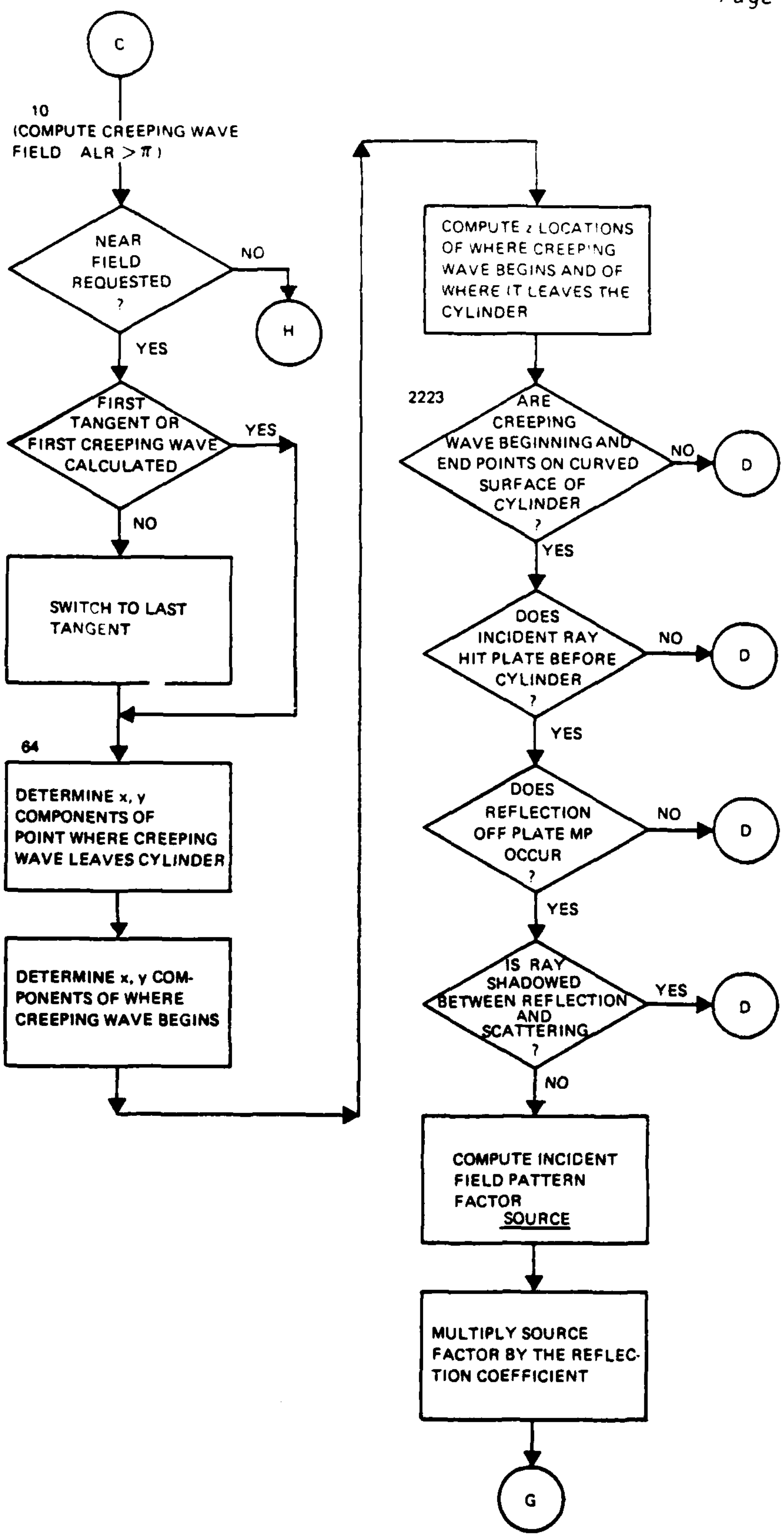
GTDDRV

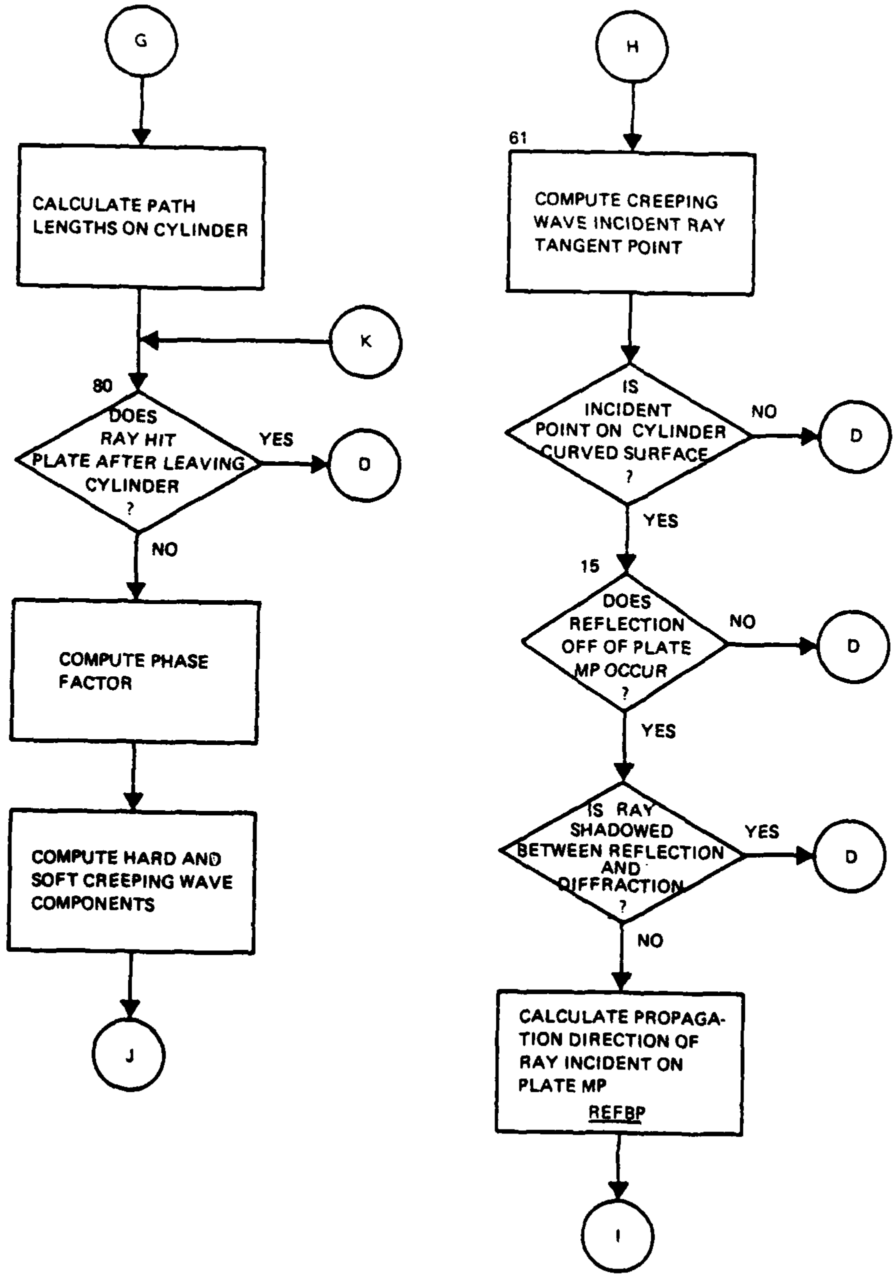
7. CALLED ROUTINES:

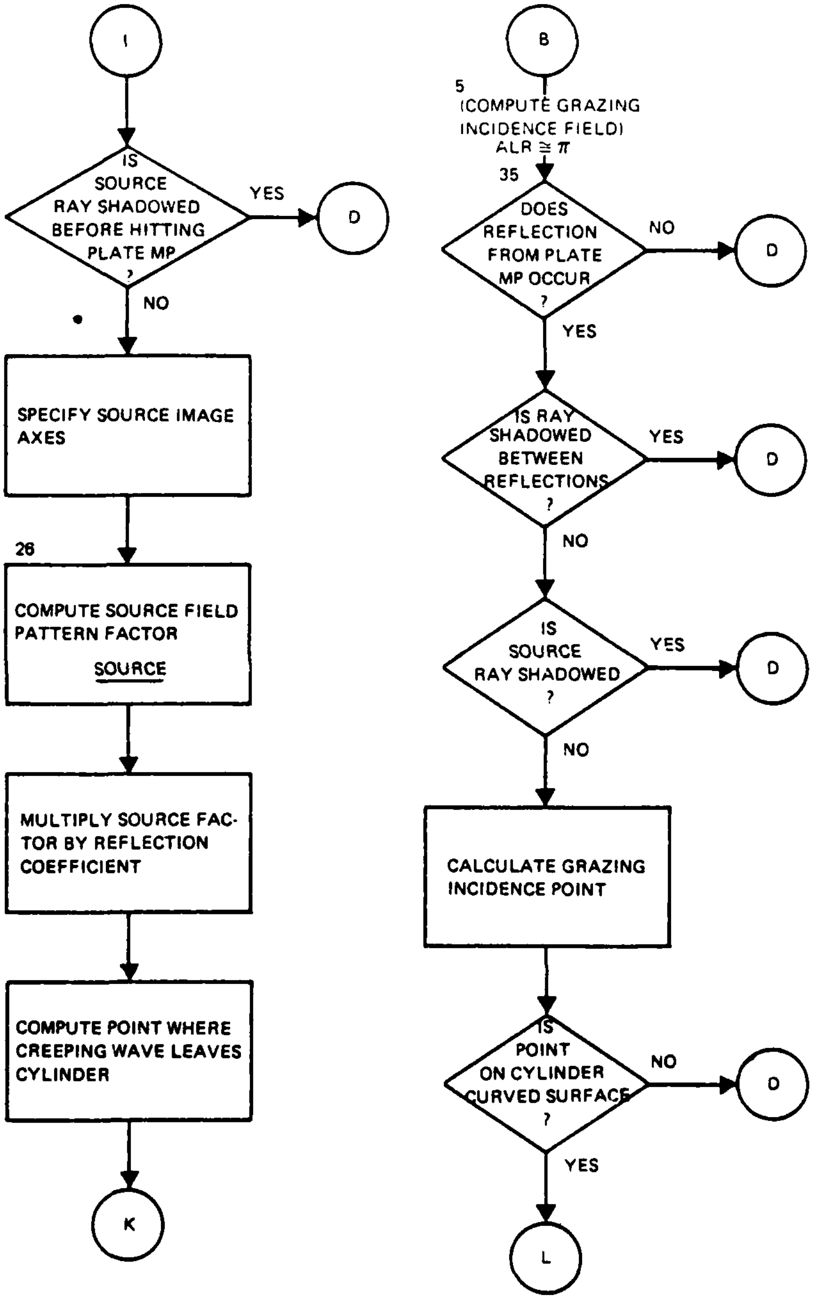
ASSIGN	QFUN
BEXP	RADCV
BTAN2	REFBP
CYLINT	RPLRCL
DQG32	SMAGNF
FCT	SOURCE
FKARG	STATIN
FRNELS	STATOT
NANDB	TANG
NFD	WLKBCK
PFUN	XYZFLD
PLAINT	

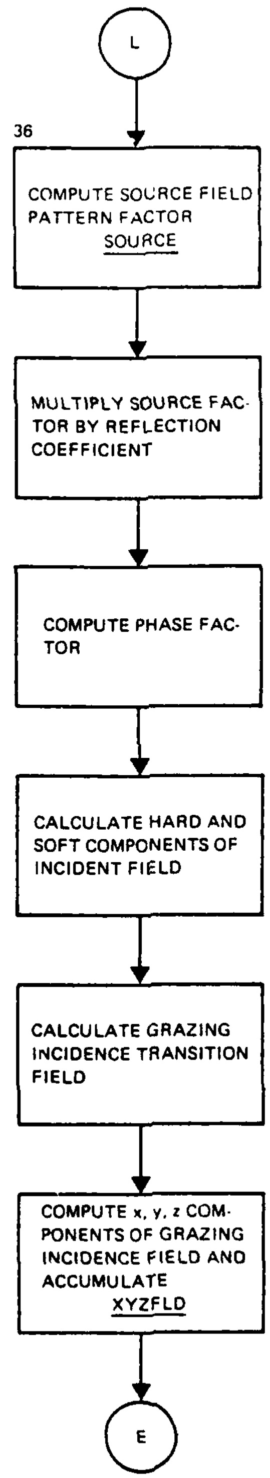

RPLSCL
INITIALIZE FIELDS TO ZERO
CAN PLATE– REFLECTED RAY ILLUMINATE CYLINDER CURVED SURFACE ?
NO
A
YES
F
42
LOOP THROUGH TANGENT VECTORS
CALCULATE ALR, THE REFLECTED RAY PHI ANGLE IN TANGENT POINT COORDINATE SYSTEM
GRAZING INCIDENCE ?
YES
B
NO
CREEPING WAVE ?
YES
C
NO
(COMPUTE REFLECTED FIELD TERMS, ALR < π)
FIND CYLINDER REFLECTION POINT AND ASSOCIATED FIELDS
RPLRCL
ARE REFLECTED FIELDS PRESENT ?
NO
D
YES
IS REFLECTION TO BE HANDLED BY OTHER TANGENT ?
YES
D
NO
SPECIFY HARD AND SOFT COMPONENTS OF FIELD INCIDENT ON CYLINDER
J
30
COMPUTE FIELD (EITHER CREEPING WAVE OR REFLECTED)
COMPUTE x, y, z COMPONENTS OF FIELD (EITHER CREEPING WAVE OR REFLECTED) AND ACCUMULATE
XYZFLD
E


E
6
ACCUMULATE TOTAL FIELDS
D
1
ANOTHER TANGENT ?
YES
F
NO
A
909
LDEBUG ON ?
NO
YES
COMPUTE FIELD MAGNITUDE
PRINT FIELD MAGNI-TUDE AND THETA AND PHI COMPONENTS ON FILE LUPRNT
1415
RETURN


C
10
(COMPUTE CREEPING WAVE
FIELD ALR > π)
NEAR FIELD REQUESTED ?
NO
H
YES
FIRST TANGENT OR FIRST CREEPING WAVE CALCULATED
YES
NO
SWITCH TO LAST TANGENT
64
DETERMINE x, y COMPONENTS OF POINT WHERE CREEPING WAVE LEAVES CYLINDER
DETERMINE x, y COMPONENTS OF WHERE CREEPING WAVE BEGINS
COMPUTE z LOCATIONS OF WHERE CREEPING WAVE BEGINS AND OF WHERE IT LEAVES THE CYLINDER
2223
ARE CREEPING WAVE BEGINNING AND END POINTS ON CURVED SURFACE OF CYLINDER ?
NO
D
YES
DOES INCIDENT RAY HIT PLATE BEFORE CYLINDER ?
NO
D
YES
DOES REFLECTION OFF PLATE MP OCCUR ?
NO
D
YES
IS RAY SHADOWED BETWEEN REFLECTION AND SCATTERING ?
YES
D
NO
COMPUTE INCIDENT FIELD PATTERN FACTOR SOURCE
MULTIPLY SOURCE FACTOR BY THE REFLECTION COEFFICIENT
G


G
CALCULATE PATH LENGTHS ON CYLINDER
K
80
DOES RAY HIT PLATE AFTER LEAVING CYLINDER ?
YES
D
NO
COMPUTE PHASE FACTOR
COMPUTE HARD AND SOFT CREEPING WAVE COMPONENTS
J
H
61
COMPUTE CREEPING WAVE INCIDENT RAY TANGENT POINT
IS INCIDENT POINT ON CYLINDER CURVED SURFACE ?
NO
D
YES
15
DOES REFLECTION OFF OF PLATE MP OCCUR ?
NO
D
YES
IS RAY SHADOWED BETWEEN REFLECTION AND DIFFRACTION ?
YES
D
NO
CALCULATE PROPAGATION DIRECTION OF RAY INCIDENT ON PLATE MP
REFBP
I


I
IS SOURCE RAY SHADOWED BEFORE HITTING PLATE MP ?
YES
D
NO
SPECIFY SOURCE IMAGE AXES
26
COMPUTE SOURCE FIELD PATTERN FACTOR
SOURCE
MULTIPLY SOURCE FACTOR BY REFLECTION COEFFICIENT
COMPUTE POINT WHERE CREEPING WAVE LEAVES CYLINDER
K
B
5
(COMPUTE GRAZING INCIDENCE FIELD)
ALR ≅ π
35
DOES REFLECTION FROM PLATE MP OCCUR ?
NO
D
YES
IS RAY SHADOWED BETWEEN REFLECTIONS ?
YES
D
NO
IS SOURCE RAY SHADOWED ?
YES
D
NO
CALCULATE GRAZING INCIDENCE POINT
IS POINT ON CYLINDER CURVED SURFACE ?
NO
D
YES
L


L
36
COMPUTE SOURCE FIELD PATTERN FACTOR
SOURCE
MULTIPLY SOURCE FACTOR BY REFLECTION COEFFICIENT
COMPUTE PHASE FACTOR
CALCULATE HARD AND SOFT COMPONENTS OF INCIDENT FIELD
CALCULATE GRAZING INCIDENCE TRANSITION FIELD
COMPUTE x, y, z COMPONENTS OF GRAZING INCIDENCE FIELD AND ACCUMULATE
XYZFLD
E

1. NAME: RWCOMS (GTD, INPUT, MOM, OUTPUT)

2. PURPOSE: To read or write common blocks on the checkpoint file.

3. METHOD: RWCOMS uses arrays the same length as each common area. These common arrays can be read from, or written to, the checkpoint file.

4. INTERNAL VARIABLES:

VARIABLES	DEFINITION
ADEBG	Array the same length as ADEBUG common
AMPZJ	Array the same length as AMPZIJ common
ARGCM	Array the same length as ARGCOM common
CSTM	Array the same length as CSYSTM common
DFDT	Array the same length as DEFDAT common
FLDCM	Array the same length as FLDCOM common
GEODT	Array the same length as GEODAT common
GTDDT	Array the same length as GTDDAT common
ICOM	Index to commons
ICOMSV	Save the index
IEOF	End-of-file indicator
IFILE	File number for input or output (CHKPNT or MODCHK)
INDXP1	INDXWB+1
INDXWB	Size of array NAMOLD
INTM	Array the same length as INTMAT common
IOFLS	Array the same length as IOFLES common
IWBSAV	Saved value of walk back table index
JNCN	Array the same length as JUNCOM common
MDLE	Array the same length as MODULE common

NAMCOM	Contains the names of commons written to the checkpoint file
NAME	Name of common block being read in
NAMOLD	Array to store first four locations of walkback table
NCOMSZ	Array containing the length of each common
NMWRDS	Number of words in common being read
NREAD	Input variable that will indicate a read or write
NUMCOM	Number of commons
PARTB	Array the same length as PARTAB common
SCNPR	Array the same length as SCNPAR common
SGMNT	Array the same length as SEGMNT common
SMSTR	Array the same length as SYMSTR common
SYSFL	Array the same length as SYSFIL common
TEMP	Array the same length as TEMP01 common

5. I/O VARIABLES:

A. INPUT

INPUT	LOCATION
ADEBG	/ADEBUG/
AMPZJ	/AMPZIJ/
ARGCM	/ARGCOM/
CSTM	/CSYSTM/
DFDT	/DEFDAT/
FLDCM	/FLDCOM/
GEODT	/GEODAT/
GTDDT	/GFDDAT/
IFILE	F.P.

RWCOMS (GTD, INPUT, MOM, OUTPUT)

	IOFLS	/IOFLES/
	ISOFF	/ADEBUG/
	ISON	/ADEBUG/
	JNCN	/JUNCOM/
	LUPRNT	/ADEBUG/
	MDLE	/MODULE/
	MXWALK	/ADEBUG/
	NAMRTN	/ADEBUG/
	NREAD	F.P.
	NRSUBS	/ADEBUG/
	PARTB	/PARTAB/
	SCNPR	/SCNPAR/
	SGMNT	/SEGMNT/
	SMSTR	/SYMSTR/
	SYSFL	/SYSFIL/
	TEMP	/TEMP01/
B.	OUTPUT	LOCATION
	ADEBG	/ADEBUG/
	AMPZJ	/AMPZ1J/
	ARGCM	/ARGCOM/
	CSTM	/CSYSTM/
	DFDT	/DEFDAT/
	FLDCM	/FLDCOM/
	GEODT	/GEODAT/

RWCOMS (GTD, INPUT, MOM, OUTPUT)

GTDDT	/GTDDAT/
IEOF	F.P.
IOFILE	/IOFLES/
IOFLS	/IOFLES/
JNCN	/JUNCOM/
MDLE	/MODULE/
NAMRTN	/ADEBUG/
NOGOFG	/ADEBUG/
NRTIMS	/ADEBUG/
PARTB	/PARTAB/
RSUMS	/ADEBUG/
SCNPR	/SCNPAR/
SGMNT	/SEGMNT/
SMSTR	/SYMSTR/
SYSFL	/SYSFIL/
TEMP	/TEMP01/

6. CALLING ROUTINES:*

RESTRT (1)

STRTUP (2,3,4)

WRTCHK (1,2,3,4)

*1 - INPUT
2 - GTD
3 - MOM
4 - OUTPUT

7. CALLED ROUTINES:

ASSIGN

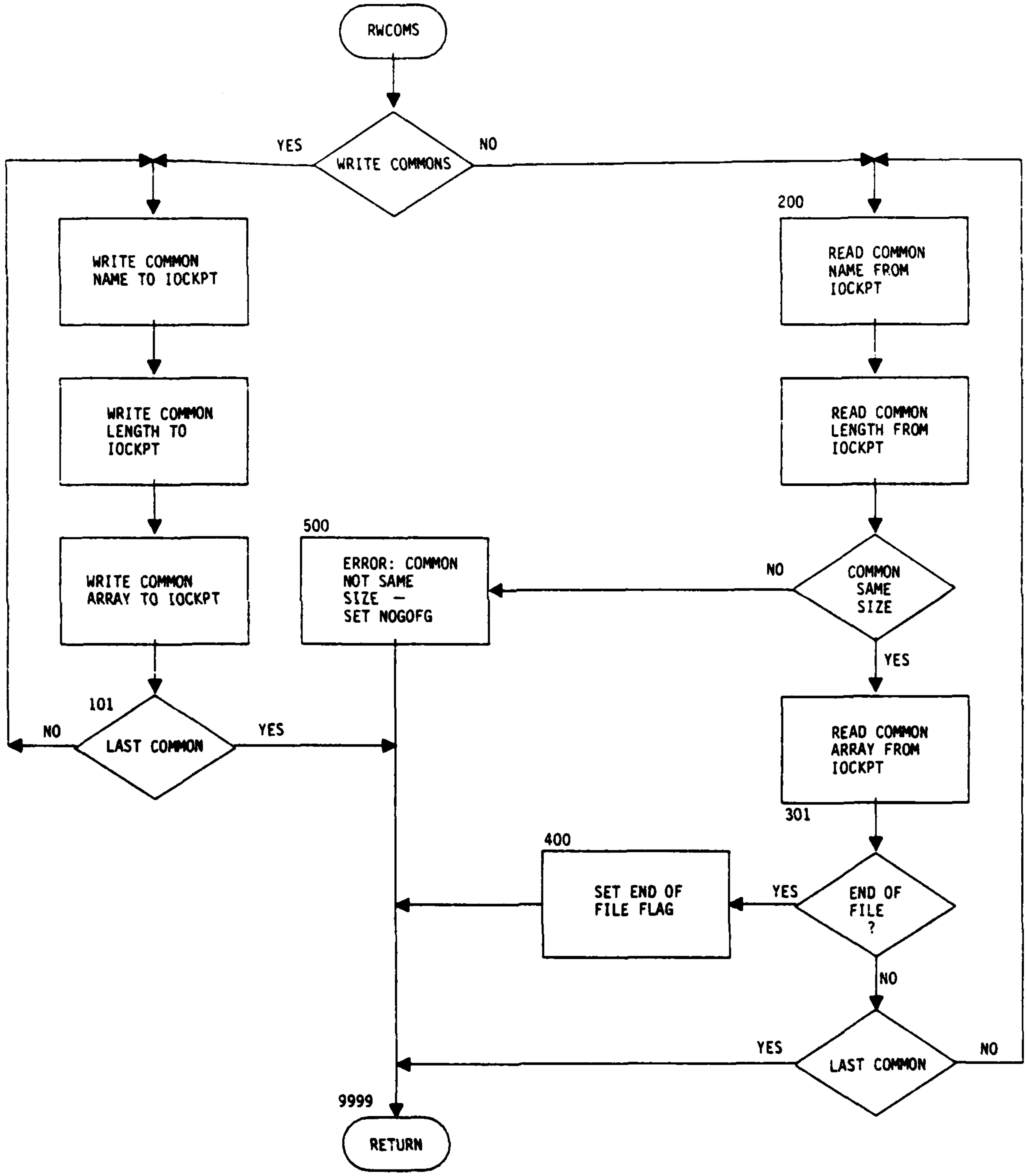
RDEFIL

STATIN

STATOT

WLKBCK

WRTFIL


RWCOMS
WRITE COMMONS
YES
NO
WRITE COMMON NAME TO IOCKPT
WRITE COMMON LENGTH TO IOCKPT
WRITE COMMON ARRAY TO IOCKPT
101
LAST COMMON
NO
YES
200
READ COMMON NAME FROM IOCKPT
READ COMMON LENGTH FROM IOCKPT
COMMON SAME SIZE
NO
YES
500
ERROR: COMMON NOT SAME SIZE — SET NOGOFG
READ COMMON ARRAY FROM IOCKPT
301
END OF FILE ?
YES
NO
400
SET END OF FILE FLAG
LAST COMMON
YES
NO
9999
RETURN

1. NAME: RWFILS (GTD, INPUT, MOM, OUTPUT)

2. PURPOSE: Read or write all data files to/from a checkpoint file.

3. METHOD: The symbol table is searched for a data file that is not null. The data set name is read/written and file attributes calculated. PUTSYM is called to handle the file-to-file transfer via the TEMP or SEGTBL array. Should TEMP not be large enough to handle one record of the file, a fatal error is generated.

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
I	Pointer to symbol table entry
IFILE	Checkpoint file number, either IOCKPT or MODCHK
IR1	Internal variable equal to zero
KGEOM	Flag indicating geometry data set
NAME	User-assigned name of data set
NBITWD	Data set bit attribute word
NDF	Internal variable to save file length while reinitializing file
NFILE	Logical unit number for data set
NPRBUF	Number of records which will fit into buffer array
NPRELM	Number of words per data set element
NPRREC	Number of words on data set record
NREAD	Flag indicating whether to read (ISOFF) or write (ISON) files
NRECS	Internal variable equal to NPRREC
NS	Hollerith equivalent of NAME
NUMREC	Number of records contained in data set

5. I/O VARIABLES:

A. INPUT

INPUT	LOCATION
IFILE	F.P.
ISOFF	/ADEBUG/
ISON	/ADEBUG/
KBCPLX	/PARTAB/
KBGEOM	/PARTAB/
KOLBIT	/PARTAB/
KOLCOL	/PARTAB/
KOLLOC	/PARTAB/
KOLNAM	/PARTAB/
KOLROW	/PARTAB/
LUPRNT	/ADEBUG/
NDATBL	/PARTAB/
NDFILE	/IOFLES/
NPDATA	/PARTAB/
NREAD	F.P.
NTEMPS	/TEMP01/
SEGTBL	/SEGMNT/
TEMP	/TEMP01/

B. OUTPUT

OUTPUT	LOCATION
IERRF	/ADEBUG/

6. CALLING ROUTINES:*

RESTRT (1)

STRTUP (2,3,4)

WRTCHK (1,2,3,4)

7. CALLED ROUTINES:

ASSIGN

CLSFIL

CONVRT

IBITCK

OPNFIL

PUTSYM

RDEFIL

STATIN

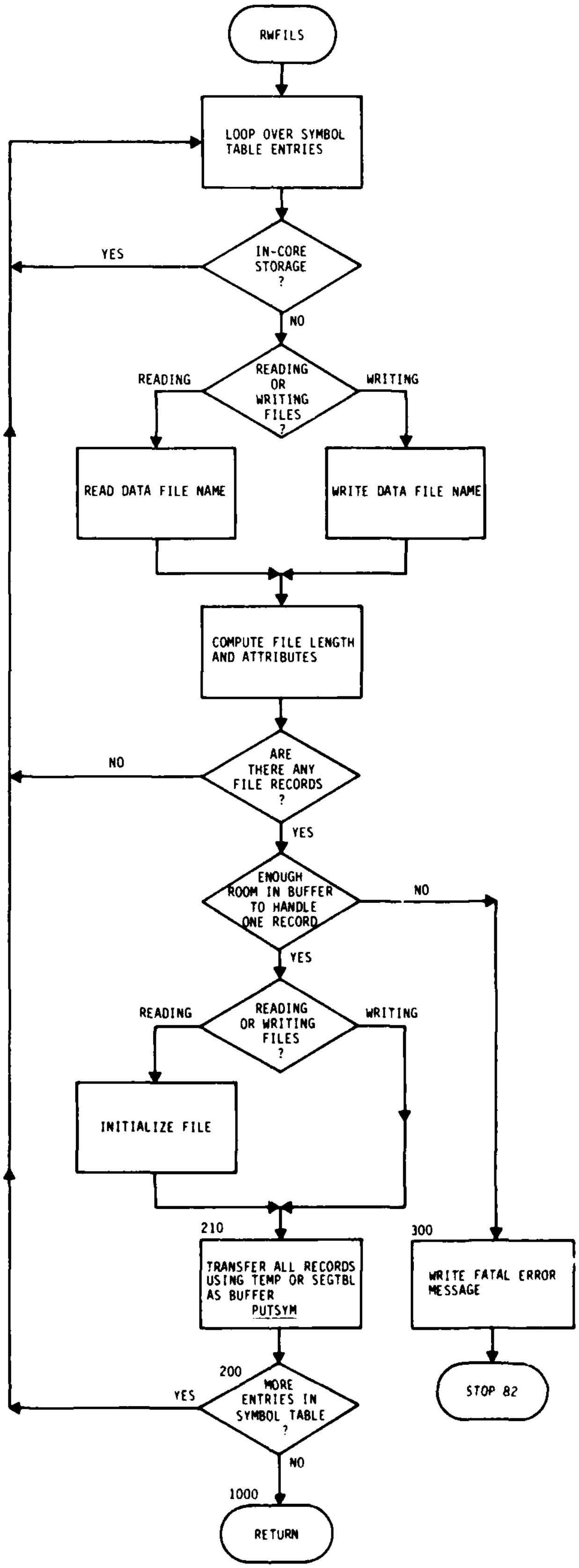
STATOT

WLKBCK

WRTFIL

* 1 - INPUT
2 - GTD
3 - MOM
4 - OUTPUT

RWFILS (GTD, INPUT, MOM, OUTPUT)



1. NAME: SCALE2 (MOM, OUTPUT)

2. PURPOSE: To scale a linear axis.

3. METHOD: Given a minimum value XMIN, a maximum value XMAX, and the number of intervals N, SCALE2 finds a new maximum XMAXP, a new minimum XMINP, and the size of the intervals DIST.

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
A	Approximate interval size
AL	Log_{10} of A
B	A scaled
DEL	Round-off error
DIST	Distance between each scale mark
FM1	Minimum value divided by the interval size
FM2	Maximum value divided by the interval size
M1	Variable used to keep points within the minimum value
M2	Variable used to keep points within the maximum value
N	Input number of intervals
NAL	Variable used to make the minimum/maximum interval large enough
NP	Check for the number of intervals
VINT	Array containing number of interval sizes
XMAX	Input maximum value
XMAXP	Output maximum value
XMIN	Input minimum value
XMINP	Output minimum value

5. I/O VARIABLES:

A. INPUT — LOCATION

LUPRNT	/ADEBUG/
N	F.P.
XMAX	F.P.
XMIN	F.P.

B. OUTPUT — LOCATION

DIST	F.P.
XMAXP	F.P
XMINP	F.P.

6. CALLING ROUTINE:

PAGPLT

7. CALLED ROUTINES:

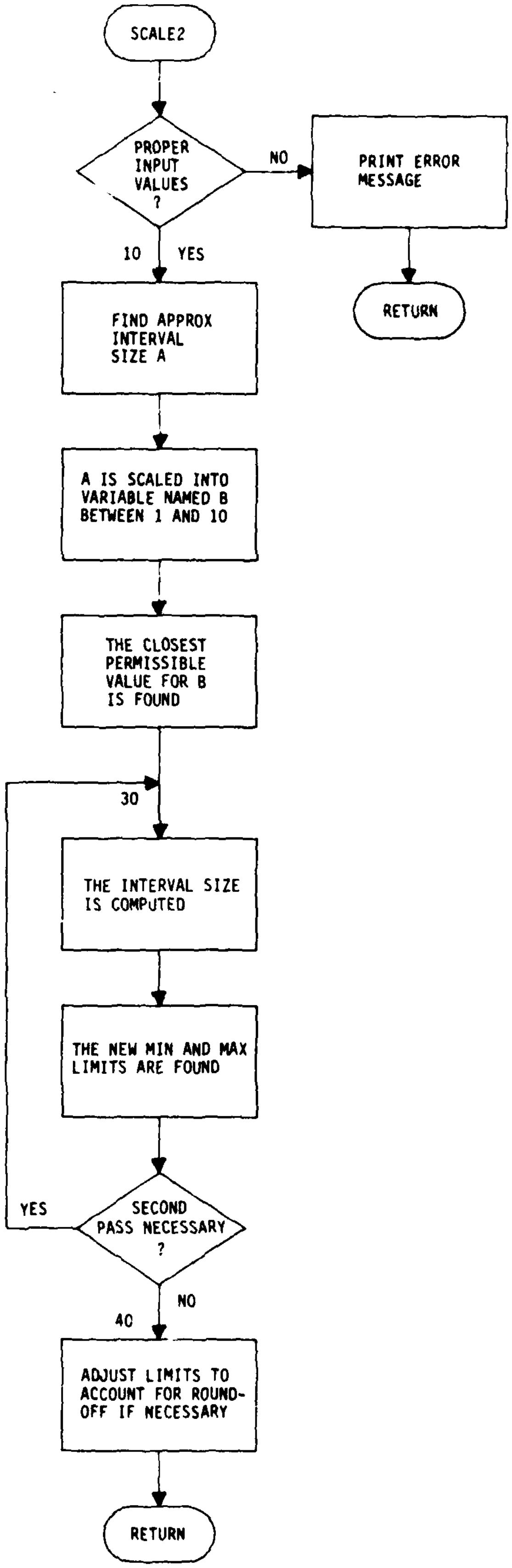
ASSIGN

STATIN

STATOT

WLKBCK

SCALE2 (MOM, OUTPUT)



1. NAME: SCALE3 (MOM, OUTPUT)

2. PURPOSE: To scale a log axis.

3. METHOD: Given a minimum value XMIN, a maximum value XMAX, and N intervals where N is greater than one, SCALE3 finds a new range XMINP and XMAXP divided into N equal logarithmic intervals. The ratio of adjacent uniformly spaced scale values is DIST.

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
A	Approximate interval size
AL	Log_{10} of A
B	A scaled
DEL	Round-off error
DIST	Output distance between scale marks
DISTL	Approximate interval size
FM1	Approximate minimum limits
FM2	Approximate maximum limits
FN	Number of intervals
M1	Minimum limit factor
M2	Maximum limit factor
N	Input number of decades
NAL	Integer power of the full interval
NP	Approximate number of decades
NX	Minimum power
VINT	Integer containing number of decades
XMAX	Input maximum value
XMAXL	Logarithmic value of XMAX

XMAXP	Output maximum value
XMIN	Input minimum value
XMINL	Logarithmic value of XMIN
XMINP	Output minimum value

5. I/O VARIABLES:

A.	INPUT	LOCATION
	LUPRNT	/ADEBUG/
	N	F.P.
	XMAX	F.P.
	XMIN	F.P.
B.	OUTPUT	LOCATION
	DIST	F.P.
	XMAXP	F.P.
	XMINP	F.P.

6. CALLING ROUTINE:

PAGPLT

7. CALLED ROUTINES:

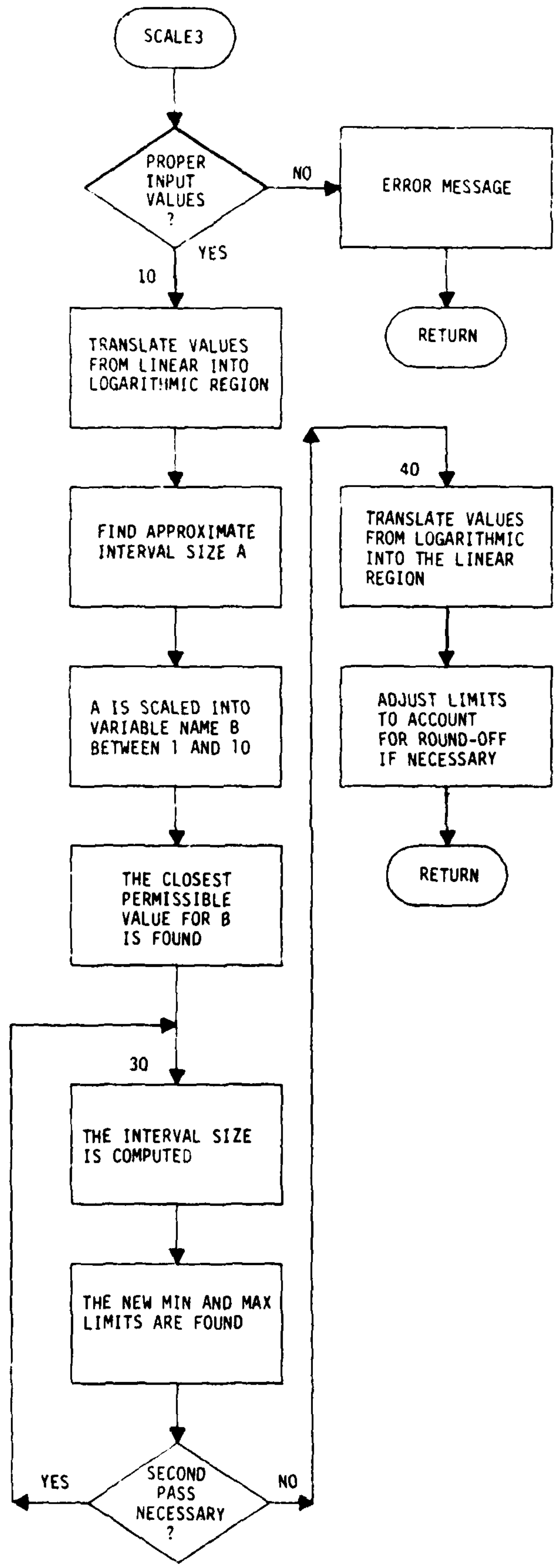
ASSIGN

STATIN

STATOT

WLKBCK

SCALE3 (MOM, OUTPUT)



1. NAME: SCAN (INPUT)

2. PURPOSE: Scan the input command and generate the scan tables for the parsing routine.

3. METHOD: SCAN breaks up the input command text into fields. These are numeric, alpha, keyword, and operator fields. The numeric field is converted into an integer or floating point number and put in the NVAL or VAL array. The alpha field is packed into the NVAL array. Keyword fields have the keyword number put in the NVAL array. The operator number is put in the NVAL array. Then a field code for each will be put in the NCODE array.

   When the SCAN table is completed, the next command is read to look for a possible end of file before the END command.

   If the IGNORE flag is on, the scan table is scanned for monadic signs. These signs are added to the number that follows it in the SCAN table.

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
FIRST	This flag tells SCAN that the input data are the first of this record
FRAC	Fractional portion of a floating point number
IFOUND	This flag tells SCAN that the exponent was found for this number
INTOVR	Flag that gets set when a number has too many digits
IP	Exponent sign
IPROVR	Flag for too many digits in the exponent
IPWR	Exponent for a number
IS	Sign of numbers in SCAN table, used in compressing tables
ISHIFT	Byte shifter
NCOMCD	Flag for comment card

NDCARD	Variable containing the code for the END command
NDXEND	Index to the NCODES array for the keyword END
NFLDS	Number of entries in the SCAN table
NP1	Index N plus one
NTABSV	Saves the value of NTAB
NTAB1	NTAB plus one
NUMCHR	Number of characters in an alpha field
NUMDEC	Number of decimals in a number
NUMFLD	Field counter
NUMREC	Record counter
NXTCHR	Next character in a field

5. I/O VARIABLES:

A. INPUT

INPUT	LOCATION
IBLANK	/SCNPAR/
ICOMMA	/SCNPAR/
IDIG	/SCNPAR/
IGNORE	/SCNPAR/
IMINUS	/SCNPAR/
IPER	/SCNPAR/
IPLUS	/SCNPAR/
IRIGHT	/SCNPAR/
ISLASH	/SCNPAR/
ISOFF	/ADEBUG/
ISON	/ADEBUG/

ISTAR	/SCNPAR/
ISYMBL	/SCNPAR/
JDIG	/SCNPAR/
KWEND	/PARTAB/
KWNAME	/PARTAB/
LETR	/SCNPAR/
LSTCOL	/SCNPAR/
LUPRNT	/ADEBUG/
LUTASK	/ADEBUG/
MXANCT	/SCNPAR/
MXEXFP	/SCNPAR/
MXFPCT	/SCNPAR/
MXINCT	/SCNPAR/
MXSYMB	/SCNPAR/
NBYTSZ	/ADEBUG/
NCARD	/SCNPAR/
NCODES	/PARTAB/
NCOMCH	/SCNPAR/
NCONCH	/SCNPAR/
NDFILE	/IOFLES/
NTALPH	/ADEBUG/
NTEND	/ADEBUG/
NTFLPT	/ADEBUG/
NTINT	/ADEBUG/
NTKEYW	/ADEBUG/

NTSYMB	/ADEBUG/
NVALMX	/SCNPAR/
B. OUTPUT	LOCATION
NARGS	/SCNPAR/
NCARD	/SCNPAR/
NCARDS	/SCNPAR/
NCCARD	/SCNPAR/
NCHAR	/SCNPAR/
NCODE	/SCNPAR/
NDFILE	/IOFLES/
NOGOFG	/ADEBUG/
NSCNER	/SCNPAR/
NSCOL	/SCNPAR/
NTAB	/SCNPAR/
NVAL	/SCNPAR/
VAL	/SCNPAR/

6. CALLING ROUTINES:

INPDRV

WYRDRV

7. CALLED ROUTINES:

ASSIGN

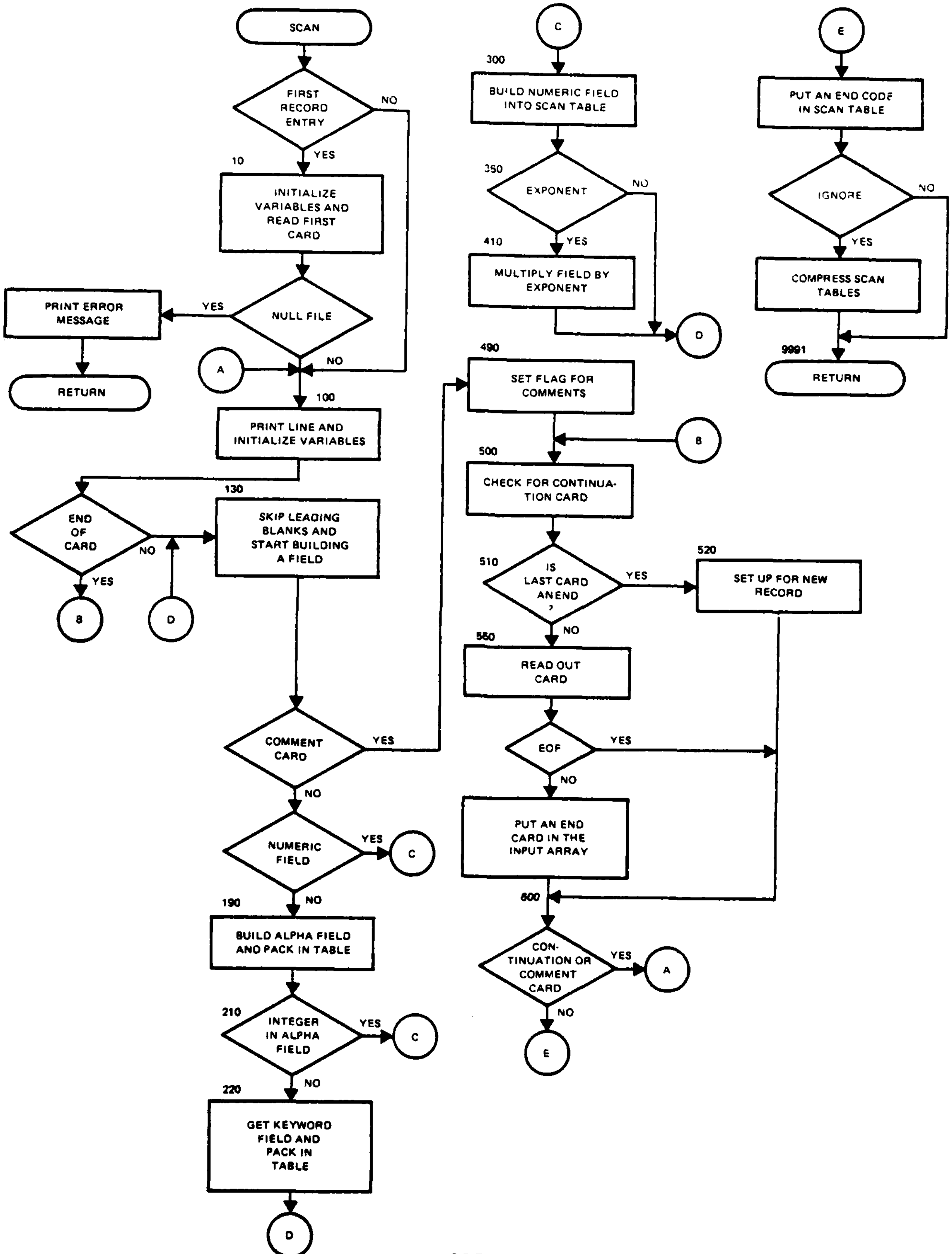
GETKWD

STATIN

STATOT

WLKBCK

SCAN (INPUT)



SCAN
FIRST RECORD ENTRY
NO
YES
10
INITIALIZE VARIABLES AND READ FIRST CARD
NULL FILE
YES
PRINT ERROR MESSAGE
RETURN
NO
A
100
PRINT LINE AND INITIALIZE VARIABLES
END OF CARD
NO
YES
B
D
130
SKIP LEADING BLANKS AND START BUILDING A FIELD
COMMENT CARD
YES
NO
NUMERIC FIELD
YES
C
NO
190
BUILD ALPHA FIELD AND PACK IN TABLE
210
INTEGER IN ALPHA FIELD
YES
C
NO
220
GET KEYWORD FIELD AND PACK IN TABLE
D
C
300
BUILD NUMERIC FIELD INTO SCAN TABLE
350
EXPONENT
NO
YES
410
MULTIPLY FIELD BY EXPONENT
D
490
SET FLAG FOR COMMENTS
B
500
CHECK FOR CONTINUATION CARD
510
IS LAST CARD AN END ?
YES
520
SET UP FOR NEW RECORD
NO
550
READ OUT CARD
EOF
YES
NO
PUT AN END CARD IN THE INPUT ARRAY
600
CONTINUATION OR COMMENT CARD
YES
A
NO
E
E
PUT AN END CODE IN SCAN TABLE
IGNORE
NO
YES
COMPRESS SCAN TABLES
9991
RETURN

1. NAME: SCLRPL (GTD)

2. PURPOSE: To compute the unobstructed electric field from a unit source scattered by an elliptic cylinder and then reflected by plate MP in the given far-field observation direction or to the given near-field observation point. The cylinder scattering can occur by a creeping wave and a reflected ray or by two creeping waves.

3. METHOD: SCLRPL is the driver routine which directs all the ray tracing physics and field calculations for determining the electric field scattered by a cylinder and then reflected by plate MP in a given far-field direction or to the given near-field observation point. The ray paths are shown in figures 1 and 2.

   The code begins by making two special checks. One check is to determine if the source location is in the paraxial region beyond the end caps such that it cannot illuminate the curved surface of the cylinder. The other check is to make sure the ray path which leaves the cylinder can cause reflection to occur from plate MP in the correct direction. If the result of either of these checks is such that cylinder-scattered plate-reflected fields cannot be found, the code will print debug information, if requested, on file LUPRNT. Control is then returned to the calling routine. If the correct interaction can be found, the tangent vectors from the source to the cylinder are specified. Ray tracing and field computations are performed for both of these tangents. The type of field calculation is based on the value ALR. ALR is the reflected ray phi angle in the tangent coordinate system. If it is approximately π, grazing incidence occurs. If ALR is greater than π, a cylinder creeping wave occurs for this tangent. If ALR is less than π, a reflected wave occurs. After performing the ray path calculations and field calculations, the code will check to see if the second tangent remains to be addressed. If it does, a new value of ALR will be computed and the appropriate field calculations will be performed. If both tangents have been addressed, debug information (if requested) will be printed on file LUPRNT. The debug information consists of the total field magnitude and the theta and phi components of the field. Control is then returned to the calling routine.

   If ALR is less than π, it is possible that a reflected ray can occur from the cylinder. Subroutine RCLRPL calculates the ray path for a ray reflected by a cylinder and then reflected by a plate. It also computes the incident field upon the cylinder at the cylinder reflection point and other geometry-specific terms. These terms and field are passed to SCLRPL through common block FUDGJ. The ray spreading radii and phase factor are computed in this subroutine based upon parameters from common block FUDGJ. Then the field computations can begin. First, the cylinder-reflected field is computed. Then the field reflected from plate MP is computed in

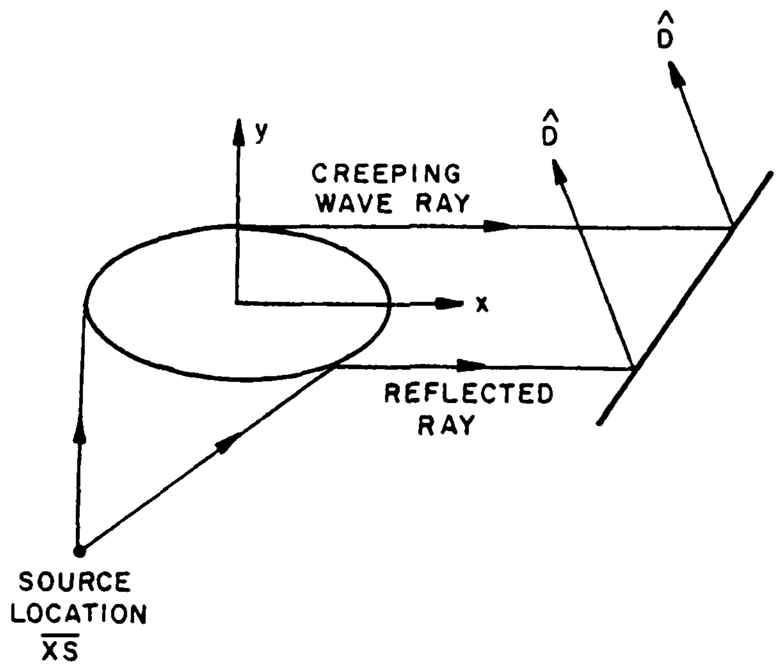


Figure 1. Illustration of Ray Scattered by the Cylinder and Reflected by a Plate into the Far Field

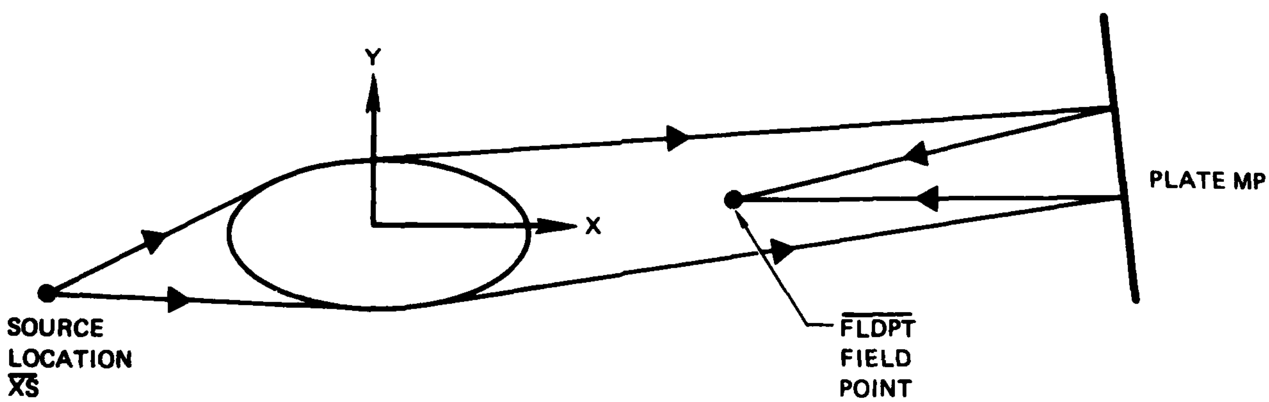


Figure 2. Illustration of Ray Scattered by Cylinder and Reflected by Plate to the Near-Field Observation Point

theta and phi components. This is the total cylinder-relected plate-reflected field. Subroutine XYZFLD is called to compute the x, y, z components of the total field and to accumulate them with other fields from previous interactions.

If ALR is approximately equal to π, grazing incidence occurs. The grazing incidence portion of the code first checks to make sure that reflection from plate MP can occur. If it cannot, the code will check to see if the second tangent remains and will address it appropriately. If reflection from plate MP can occur, the ray path is checked to see if it is shadowed anywhere. If it is, the code will check for another tangent. If shadowing did not occur the grazing incidence point is computed. This point is checked to make sure that it is on the curved surface of the cylinder. The source field pattern factor is found by calling subroutine SOURCE. Next, the phase factor is computed. The hard and soft theta and phi components of the cylinder field are now found. The grazing incidence-scattered field is now computed. From this the total field being made up of the grazing incidence-scattered field and the field reflected from the plate is computed in theta and phi components. The x, y, z components are computed by calling subroutine XYZFLD.

If ALR is greater than π, a creeping wave can occur from the cylinder. The location of the point at which the creeping wave leaves the cylinder and the point at which the creeping wave begins on the cylinder are computed in two different manners depending upon whether near field or far field was requested. For the computation sequence, see the accompanying flowchart. While in the separate field computation paths, the code checks the ray from the source to the cylinder for obstructions. If the path is blocked, the code proceeds to the next tangent. If the path is clear, calculations continue for this tangent. The incident source field pattern factor is computed by calling subroutine SOURCE. For both near field and far field, the code checks to see if reflection can occur from plate MP. If it cannot, the code will look to see if a tangent remains to be addressed. If reflection does occur on plate MP, the ray from the cylinder to the plate and into the observation direction or to the observation point is checked for any obstruction. If it is obstructed, the code will proceed to the next tangent. If the ray in unobstructed, the phase factor is computed, the hard and soft creeping waves are computed, and then the total cylinder creeping wave field is computed. From this, the total field scattered by the cylinder and reflected by the plate is computed in theta and phi components. Subroutine XYZFLD is called to compute and accumulate the x, y, z components.

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
A1,A2	Field components of ray incident on plate normal and tangent to plate
A3	Determinant of polarization transformation
ALR	Phi angle defining propagation direction in tangent point coordinate system (2-D)
ALRS	Difference between ALS and ALR
ALS	Phi angle defining direction of ray from RCS origin to source in tangent point coordinate system
AN	Distance from plate MP plane to the observation field point (from subroutine IMAGE)
ANR	Distance from plate plane to XRF, the point at which the creeping wave leaves the cylinder (from subroutine IMAGE)
BX,BY,BZ	X,Y,Z components of polarization unit vector of soft component field incident on cylinder (parallel to cylinder surface and normal to incident field propagation direction)
C11,C12,C21,C22	Coefficients used to convert polarization from theta and phi components in RCS to components normal and tangent to plate (and vice-versa)
CCC	Real part of Fresnel integral (from subroutine FRNELS)
CF	Phase term and ray spreading factor
CFH	Hard transition field coefficient
CFS	Soft transition field coefficient
DEPH	Phi component of transition field in RCS
DETH	Theta component of transition field in RCS

DHIT	Distance from source to plate hit point (from subroutine PLAINT)
DHJT	Distance from where ray leaves cylinder and hits plate MP (from subroutine PLAINT)
DHT	Distance to hit point (from subroutine PLAINT and CYLINT)
DICOEF	X,Y, and Z components of incident ray direction on cylinder in RCS
DIJ	X-Y plane vector from a source tangent to the point the creeping wave leaves the cylinder
DIJXDJ	Cross product of DIJ and DJT
DIT	Incident ray vector
DIXDIJ	Cross product of DIT and DIJ
DJ	X,Y,Z components of propagation direction of ray between cylinder and plate in RCS
DJ1	Direction unit vector towards XE1
DJ2	Direction unit vector towards XE2
DJT	X-Y plane components of observation direction
DMAG	Distance between the observation field point and the plate reflection point
EF	Theta component of source field pattern factor in RCS
EG	Phi component of source field pattern factor in RCS
EHP	Phi component of hard component of geometrical optics field incident on cylinder in RCS
EHT	Theta component of hard component of geometrical optics field incident on cylinder in RCS

EIX	X component of the source field pattern factor
EIY	Y component of the source field pattern factor
EIZ	Z component of the source field pattern factor
EP	Phi component of scattered-reflected field in RCS
ER	Dot product of cylinder tangent unit vector and reflected ray propagation direction (2-D)
ERP	Phi component of geometrical optics reflected-reflected field in RCS
ERT	Theta component of geometrical optics reflected-reflected field in RCS
ESP	Phi component of soft component of geometrical optics field incident on cylinder in RCS
EST	Theta component of soft component of geometrical optics field incident on cylinder in RCS
ET	Theta component of scattered-reflected field in RCS
FLDPTI	Near-field observation field point image location (imaged through plate MP)
FPTXY	The x-y plane location of the field point image
GM	Intermediate variable for transition function
LHIT	Logical variable set true if a plate is hit (from subroutine PLAINT and CYLINT)
LTRFJ	Logical variable set true if cylinder-reflected field is not present

LVJ	Logical variable set true the first time creeping wave computations begin
MP	Plate where reflection occurs
ORIGIN	Origin of the reference coordinate system (0., 0., 0.)
PHIR	Phi angle of incident ray direction on cylinder
PHJR	Phi angle of ray propagation direction between cylinder and plate
PHJR1	Phi angle of DJ1
PHJR2	Phi angle of DJ2
RGF	Longitudinal radius of curvature of the cylinder at the point the creeping wave leaves the cylinder
RGI	Longitudinal radius of curvature of the cylinder at the creeping wave incidence point
RT	Transverse radius of curvature of the cylinder
S	The total distance between the source point and the incident point
S1	X-Y plane distance between the source and incident point
S2	X-Y plane distance between the field point image and the point on the cylinder at which the creeping wave leaves the cylinder
SKWIG	Parameter used in transition function
SNF	Distance between plate reflection point and field point
SPHJ	Sine of PHJR
SS	Distance of path along the cylinder

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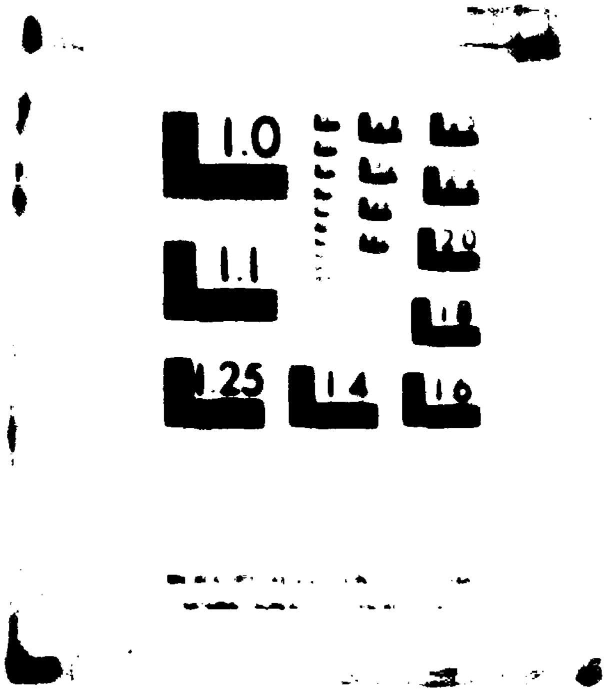

1.0
1.1
1.25

SSS	Imaginary part of Fresnel integral (from subroutine FRNLS)
STA	Elliptical angle defining the source tangent point ray location
STHJ	Sine of THJR
THIR	Theta component of incident ray direction on cylinder
THJR	Theta component of ray propagation direction between cylinder and plate
THJR1	Theta angle of DJ1
THJR2	Theta angle of DJ2
TIRM	Parameter used in transition function
TX1,TY1	X-Y components of ray from source tangent to tangent point 1 (2-D)
TX2,TY2	X-Y components of ray from source tangent to tangent point 2 (2-D)
UT	X-Y components of unit vector tangent to cylinder at tangent point
UN	X-Y components of unit vector normal to cylinder at tangent point
VO	Phi angle at which creeping wave leaves cylinder
VI	Elliptical angle used to define tangent points (2-D)
VJ	Elliptical angles defining the two tangent points on the cylinder for the vector from the field point image tangent to the cylinder
VJO	The elliptical angle defining the ray point on the cylinder at which the creeping wave leaves the cylinder
VL	Elliptical angle defining lower limit of creeping wave travel on cylinder

VT	X,Y,Z components of polarization unit vector perpendicular to plane of incidence for ray incident on plate
VU	Elliptical angle defining upper limit of creeping wave travel on cylinder
XD,YD,ZD	X,Y,Z components of direction of ray from source to cylinder tangent point (incident ray for creeping and grazing incidence cases)
XI,YI,ZI	X,Y,Z components of point where incident creeping wave (or grazing wave) meets cylinder
XPT	Point at which creeping wave begins on cylinder
XRF	X,Y,Z components of point where creeping wave leaves cylinder
XRS	X,Y,Z components of reflection point location on plate MP; also point where creeping wave leaves cylinder; also image of XRF in plate MP
XSS	Source location
XX	Transition function

5. I/O VARIABLES:

A. INPUT	LOCATION
A	/REGNEL/
AS	/GTD/
B	/REGNEL/
BTS	/DRPSCL/
CAS	/GTD/
CJ	/COMP/
CP14	/COMP/

CTC	/GEOMEL/
D	/DIR/
DP	/TMPMUV/
DT	/TMPMUV/
DTS	/BNDSCL/
ENPWJ	/FUDGJ/
ENTWJ	/FUDGJ/
ESPWJ	/FUDGJ/
ESTWJ	/FUDGJ/
FLDPT	/NEAR/
ID	/GTD/
LDEBUG	/TEST/
LNRFLD	/NEAR/
LRFS	/CLRFS/
LTRFJ	/FUDGJ/
LWPRNT	/ADEBUG/
NP	F.P.
PHER	/DIR/
PI	/PIS/
RNDLJ	/FUDGJ/
RRJ	/FUDGJ/
SAG	/GTD/
SAGP	/GTD/
SNWGJ	/FUDGJ/
SNFF	/DIST/

TNSR	/DIR/
TPI	/PIS/
TRANJ	/FUNGJ/
VN	/GEOPLA/
VTS	/BNDSCL/
VXS	/SORINF/
XNJ	/FUNGJ/
XS	/SORINF/
ZC	/GEOMEL/

B. OUTPUT LOCATION

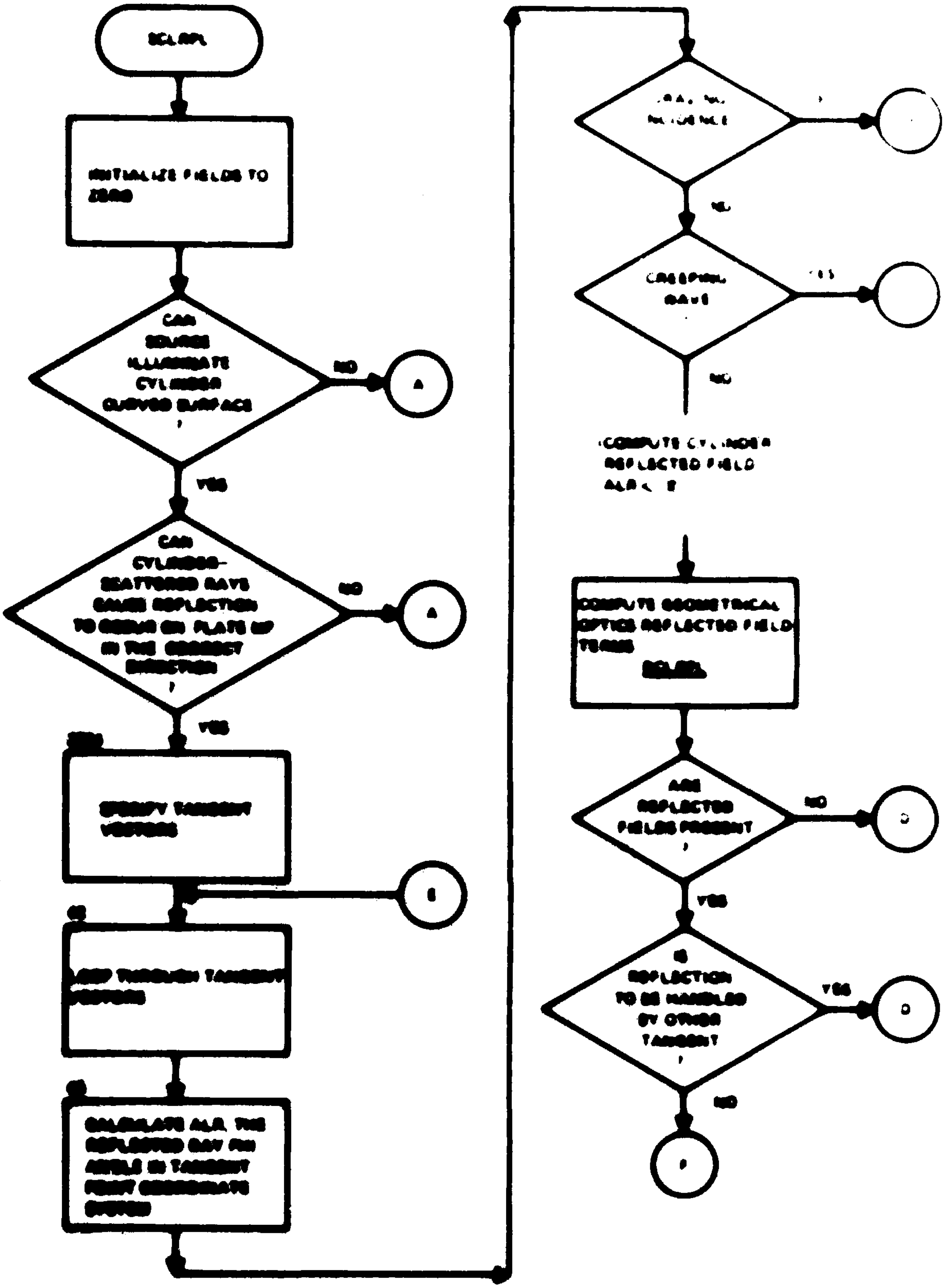
AS	/GTD/
CAS	/GTD/
EP	F.P.
ENP	F.P.
ENT	F.P.
ET	F.P.
ID	/GTD/
LNFS	/CLNFS/
SAS	/GTD/
SASP	/GTD/

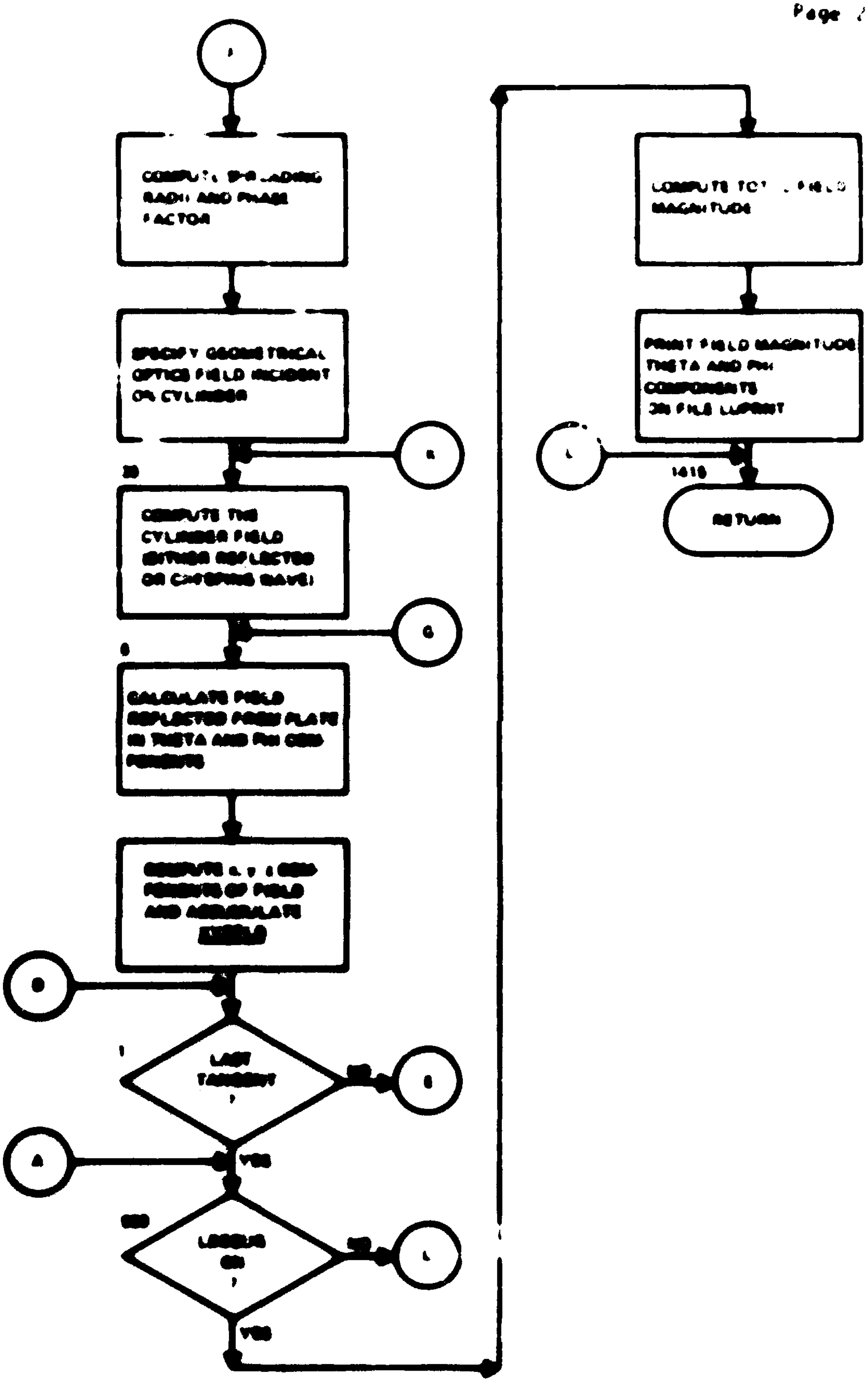
6. CALLING ROUTINE:

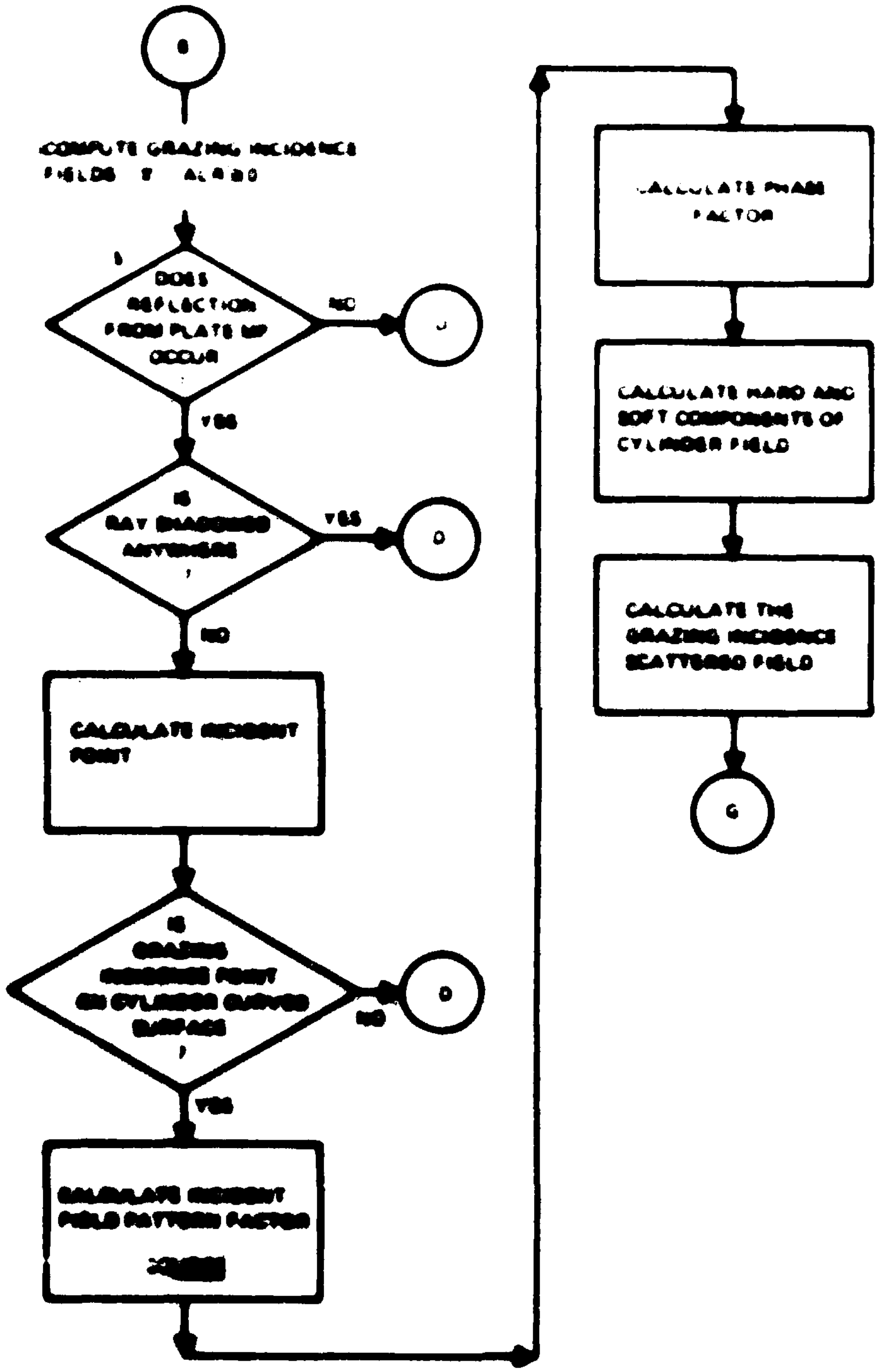
GTDDRV

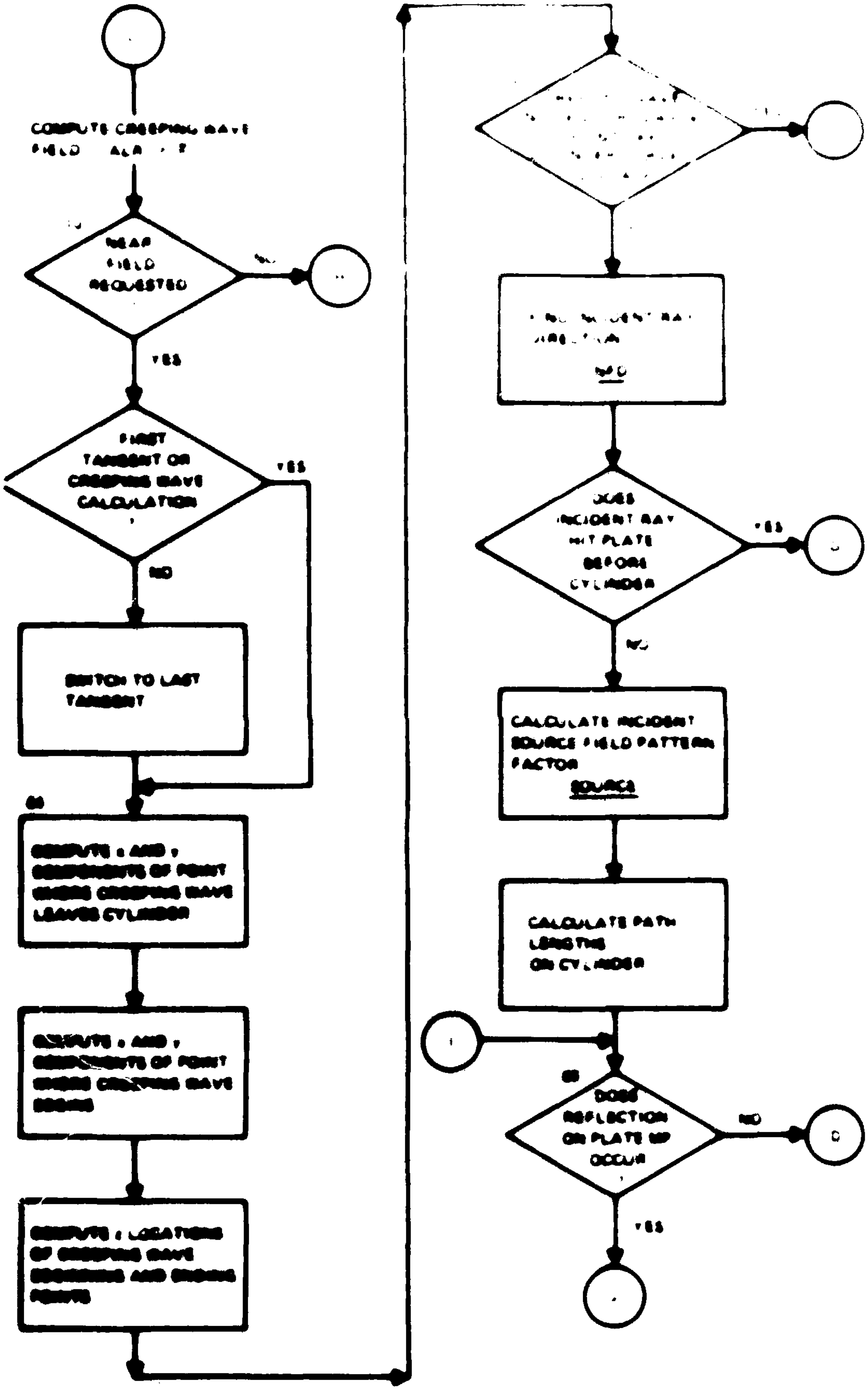
7. CALLED ROUTINES:

ASSIGN	QFUN
BEXP	RADCV
BTANP	RCLRPL
CVLINT	REFDP
DQG32	SHADWF
FCT	SOURCE
FLAGS	STATIN
FRNELS	STATOT
IMAGE	TANS
MAINS	TPWFLD
MPU	ULBDCK
PFUN	XYZFLD
PLANWT	

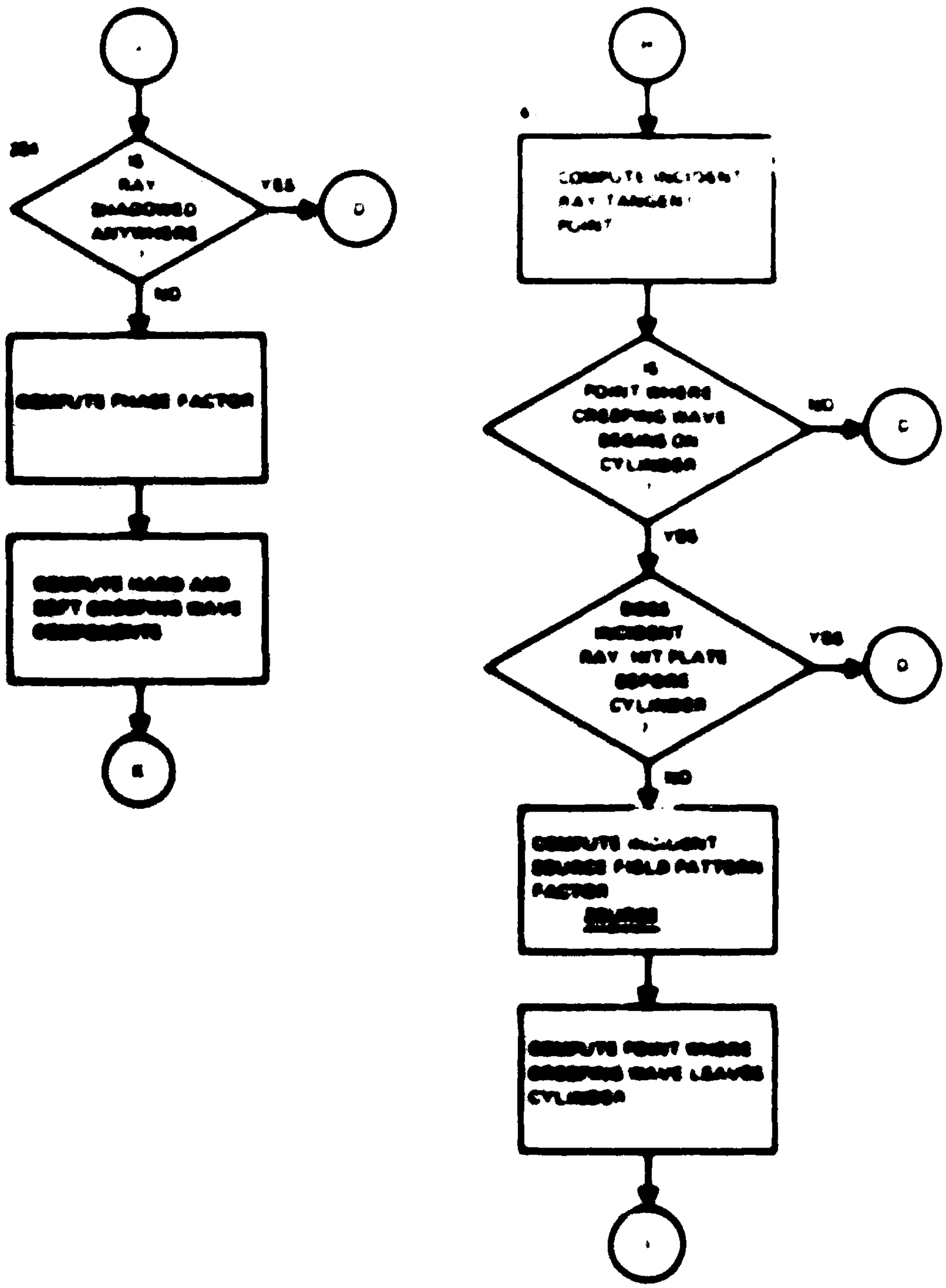

SCLRPL
INITIALIZE FIELDS TO ZERO
CAN SOURCE ILLUMINATE CYLINDER CURVED SURFACE ?
NO
A
YES
CAN CYLINDER-SCATTERED RAYS CAUSE REFLECTION TO OCCUR ON PLATE UP IN THE CORRECT DIRECTION ?
NO
A
YES
SPECIFY TANGENT VECTORS
B
LOOP THROUGH TANGENT VECTORS
NO
CREEPING WAVE
YES
NO
COMPUTE GEOMETRICAL OPTICS REFLECTED FIELD TERMS
ARE REFLECTED FIELDS PRESENT ?
NO
D
YES
IS REFLECTION TO BE HANDLED BY OTHER TANGENT ?
YES
D
NO
F


COMPUTE SPREADING RADII AND PHASE FACTOR
SPECIFY GEOMETRICAL OPTICS FIELD INCIDENT ON CYLINDER
COMPUTE THE CYLINDER FIELD (EITHER REFLECTED OR CREEPING WAVE)
CALCULATE FIELD REFLECTED FROM PLATE IN THETA AND PHI COMPONENTS
LAST TANGENT ?
NO
YES
LOBEUS ON ?
NO
YES
COMPUTE TOTAL FIELD MAGNITUDE
PRINT FIELD MAGNITUDE THETA AND PHI COMPONENTS ON FILE LUPRINT
RETURN


B
CALCULATE PHASE FACTOR
CALCULATE HARD AND SOFT COMPONENTS OF CYLINDER FIELD
CALCULATE THE GRAZING INCIDENCE SCATTERED FIELD
G
DOES REFLECTION FROM PLATE MP OCCUR
NO
YES
IS RAY SHADOWED ANYWHERE ?
YES
D
NO
CALCULATE INCIDENT POINT
IS GRAZING INCIDENCE POINT ON CYLINDER CURVED SURFACE ?
NO
D
YES
CALCULATE INCIDENT FIELD PATTERN FACTOR



COMPUTE CREEPING WAVE FIELD
NEAR FIELD REQUESTED
NO
YES
FIRST TANGENT OR CREEPING WAVE CALCULATION
YES
NO
SWITCH TO LAST TANGENT
CALCULATE INCIDENT SOURCE FIELD PATTERN FACTOR
SOURCE
CALCULATE PATH LENGTHS ON CYLINDER
DOES INCIDENT RAY HIT PLATE BEFORE CYLINDER
YES
NO
DOES REFLECTION ON PLATE OCCUR
NO
YES


IS
RAY
SHADOWED
ANYWHERE
?
YES
D
NO
COMPUTE PHASE FACTOR
COMPUTE HARD AND
SOFT CREEPING WAVE
COMPONENTS
E
COMPUTE INCIDENT
RAY TANGENT
POINT
IS
POINT WHERE
CREEPING WAVE
BEGINS ON
CYLINDER
?
NO
C
YES
DOES
INCIDENT
RAY HIT PLATE
BEFORE
CYLINDER
?
YES
D
NO
COMPUTE INCIDENT
SOURCE FIELD PATTERN
FACTOR
COMPUTE POINT WHERE
CREEPING WAVE LEAVES
CYLINDER

1. **NAME:** SCTCYL (GTD)

2. **PURPOSE:** To compute the unobstructed electric field of a unit source scattered by the elliptic cylinder's curved surface in the given far-field direction or to the given near field observation point.

3. **METHOD:** SCTCYL is the driver routine which directs all the ray tracing, physics, and field calculations for scattering by a cylinder. A Uniform Geometrical Theory of Diffraction solution (see reference A) is used to compute the reflected and diffracted fields of a source in the presence of the curved surface of an elliptic cylinder. In a given observation direction the solution contains two terms. In the lit region the solution is composed of a reflected field and the dominant creeping wave field, as illustrated in figures 1 and 2. In the shadowed region the solution is composed of a clockwise and a counterclockwise creeping wave field, as illustrated in figures 3 and 4. The reflected field and creeping wave field are modified versions of the usual GTD solution, that is, they are obtained from a uniform solution that is valid at the shadow boundaries (tangent point vector regions) and that goes to the geometrical optics solution in the deep lit region and the usual creeping wave solution in the deep shadow region. The solution is presented in reference A and on pages 112-113 of reference B.

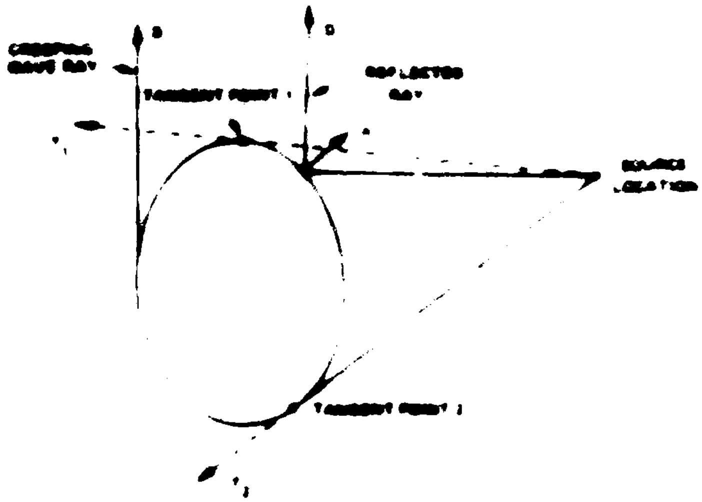


Figure 1. Illustration of Reflected and Creeping Wave Scattering by the Elliptic Cylinder for a Given Far Field Observation Direction

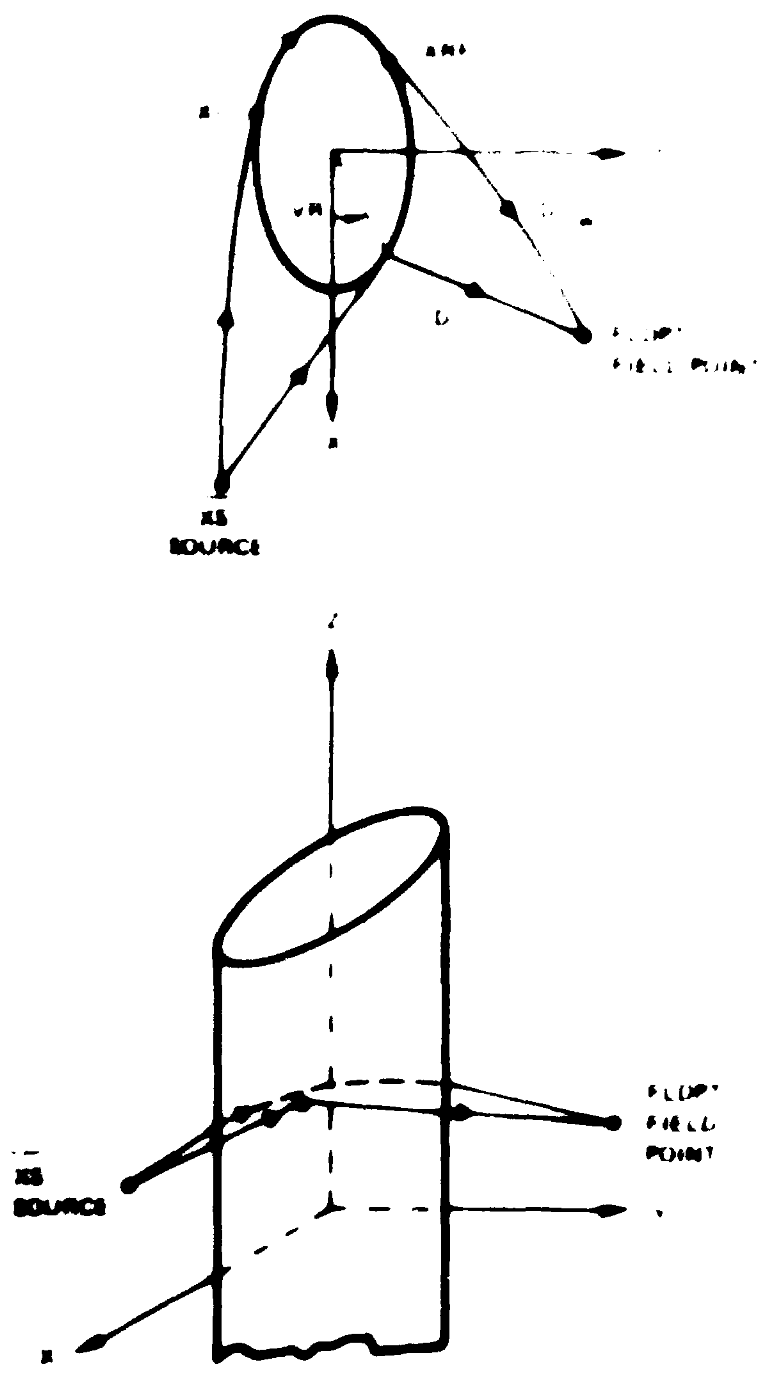


Figure 2 Illustration of Reflected and [illegible] the Elliptic [illegible]ylinder [illegible] Near [illegible] Point

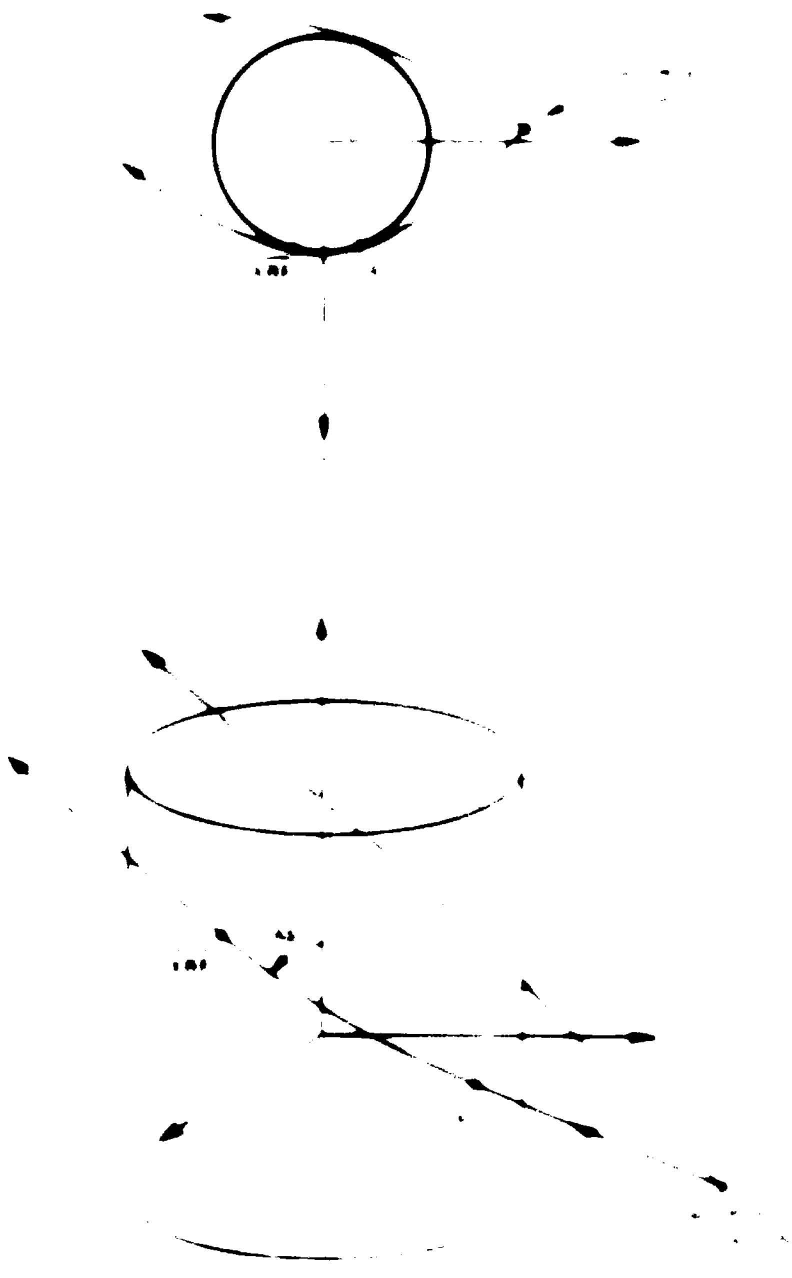


Figure [illegible] Geometry of [illegible]ing wave scattering [illegible]
Far-field Observation Direction [illegible]

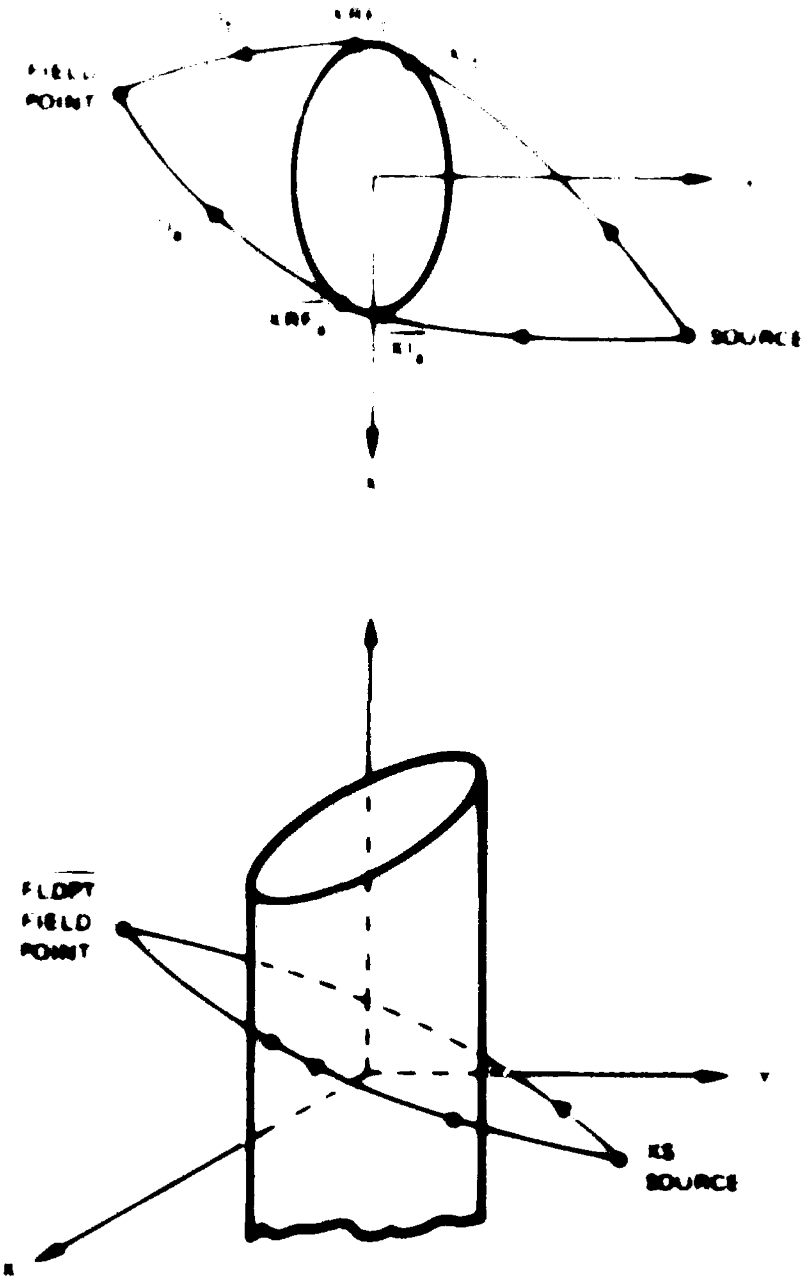


Figure 4 Illustration of Scattering by Two Creeping Wave Off the Elliptic Cylinder to a Given Near Field Observation Point

The fields are initialized to zero at the beginning of the routine. Then a check is made to make sure the propagation direction of the source ray is towards the cylinder, and another check is made to ensure that the observation point or direction is not beyond an end cap in the parallel region which the direct source ray would not reach. If proper illumination is not possible, debug information (if requested) is printed on file JPRNT and control is returned to the calling routine. If cylinder scattering is possible, the code then determines what types of scattering occur based upon the angle ALR, which is shown in Figure 5. ALR is the angle between the source ray tangent to the cylinder and the observation direction. The scattering possibilities are reflection, creeping wave, or grazing incidence. After the field associated with one tangent point or on that side of the cylinder has been computed, the field associated with the other tangent point or the new side is computed. The tangent point coordinate system is shown in Figure 6. Last, debug information (if requested) is printed on file JPRNT. Control is then returned to the calling routine.

For reflected fields, ALR is less than π. The reflection point on the cylinder is found in subroutine REFCYL. The hard and soft theta and phi components of the field incident at the cylinder reflection point (EHTH, EHPH, ESTH, ESPH) and other important parameters needed for the reflected field calculations are found in REFCYL and passed to SCTCYL in common block FUDG. The ray path is checked for obstructions in REFCYL also. The reflected field theta and phi components are computed in SCTCYL. The x, y, z components are computed and accumulated in subroutine XYZFLD.

For creeping wave fields, ALR is greater than π. The process to determine the ray path for the creeping wave is different for far field and near field calculations, as shown in the accompanying flowchart, but the end results are the same. If the ray paths are obstructed or if the path meets or leaves the cylinder at an end cap instead of on the cylinder's curved sides, the fields are left at zero. If the path is correct, the field is calculated. The x, y, z components are computed and accumulated in subroutine XYZFLD.

For grazing incidence, ALR is approximately π. The point at which the ray is incident on the cylinder is computed and checked to make sure it is between the end caps. If it is not, the fields are left at zero. If the point is correct, the field is calculated. The x, y, z components are computed and accumulated in subroutine XYZFLD.

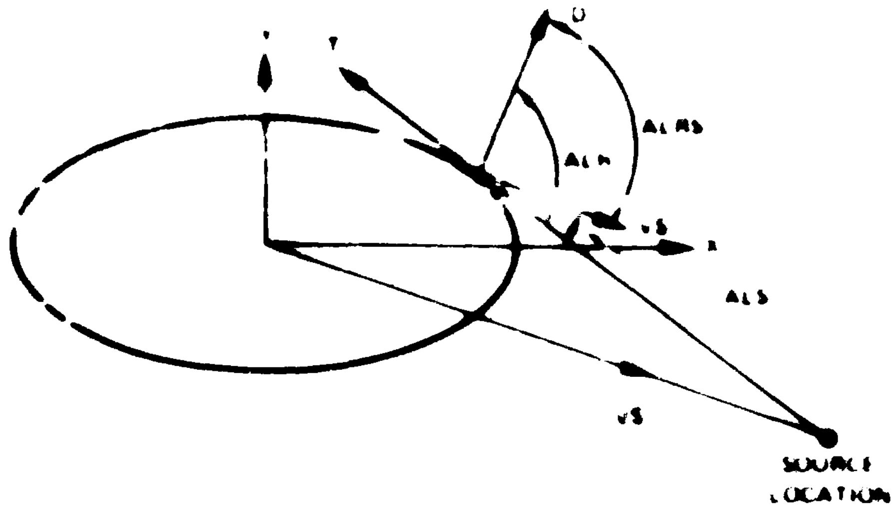


Figure 5. Geometry of Angles in Cylinder Scattering Problem

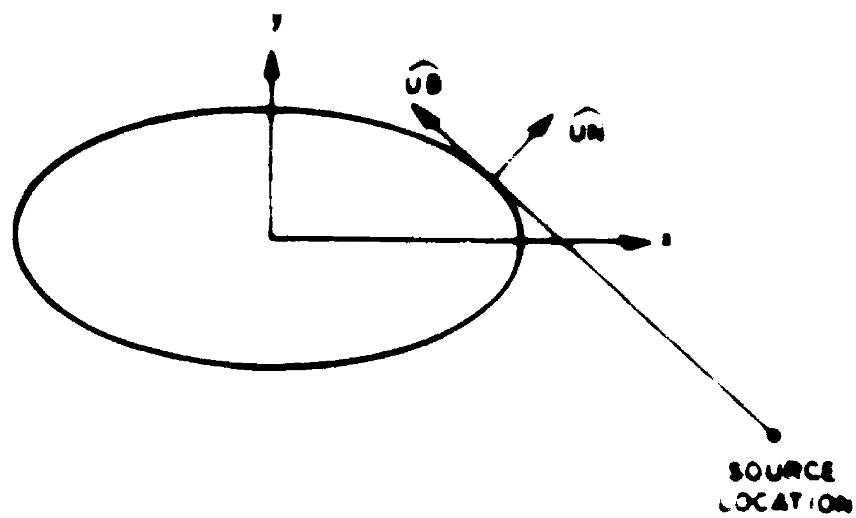


Figure 6. Illustration of Tangent Point Coordinate System

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
ALPHA	Angle between creeping wave path on cylinder and line perpendicular to the z axis
ALR	Phi angle defining radiation direction in tangent point coordinate system (2 D)
ALRS	Difference between ALS and ALR
ALS	Phi angle defining direction of ray from RCS origin to source in tangent point coordinate system; also angle between creeping wave path on cylinder and line parallel to z axis
AS	Angle between creeping wave path on cylinder and line parallel to z axis
BX,BY,BZ	X,Y,Z components of polarization unit vector of soft component of field incident on cylinder (parallel to cylinder surface and normal to incident ray propagation direction)
CCC	Real part of the Fresnel integral (from subroutine FRNELS)
CF	Complex phase and ray spreading coefficient
CFH	Hard transition field coefficient
CFS	Soft transition field coefficient
CSAS	Dot product of cylinder tangent unit vector and vector from origin to source
D	Propagation direction unit vector for ray scattered from cylinder in x,y,z RCS components
DI	Observation unit vector used in determining if observation point or direction is in the parallel region above the more positive end cap

D2	Observation unit vector used in determining if observation point or direction is in the paraxial region above the more negative end cap
DEPH	Phi component of transition field in RCS
DETH	Theta component of transition field in RCS
DHIT	Distance from source to hit point (from PLAINT)
DICOEF	X,Y,Z components of unit vector of propagation direction of ray incident on cylinder
DIJ	X-Y plane vector from a source tangent to the point the creeping wave leaves the cylinder
DIJXDJ	Cross product of DIJ and DJT
DIT	Incident ray vector
DIXDIJ	Cross product of DIT and DIJ
DJT	X-Y plane components of observation direction
DMAG	Distance between point at which creeping wave leaves cylinder and the near field observation point
EF	Pattern factor for theta component of incident field in RCS
EG	Pattern factor for phi component of incident field pattern factor in RCS
EHP	Phi component of hard component of field incident on cylinder or creeping wave field in RCS
EHT	Theta component of hard component of field incident on cylinder or creeping wave field in RCS
EIX,EIY,EIZ	X,Y,Z components of incident field pattern factor

EP	Phi component of cylinder E field
ER	Dot product of unit vector tangent to cylinder and the propagation direction unit vector
ERP	Phi component of geometrical optics reflected field
ERT	Theta component of geometrical optics reflected field
ESP	Phi component of soft component of field incident on cylinder or creeping wave field in RCS
EST	Theta component of soft component of field incident on cylinder or creeping wave field in RCS
ET	Theta component of cylinder E-field
FI	Parameter used in transition function
FPTXY	The x-y plane location of the near-field observation point
GN	Variable used in transition function
I	Variable used to step through tangent points
IC	Index variable
LHIT	Set true if ray hits a plate (from PLAINT)
LRFCT	Set true when creeping wave computations begin
LTRF	(Returned from RPLRCL) set true if geometrical optics cylinder reflected field does not exist
LWJ	Set true first time near-field computations begin
ORIGIN	The origin of the reference coordinate system (0., 0., 0.)

PHIR	Phi component of propagation direction of ray incident on cylinder
PHSR1	Phi angle of D1
PHSR2	Phi angle of D2
RRF	Radius of curvature of cylinder at point XRF in x-y plane
RGI	Radius of curvature of cylinder at incident ray point on cylinder in x y plane
RT	Transverse radius of curvature of the cylinder
S	The total distance between the source point and the incident point
S1	X-Y plane distance between the source and incident points
S2	X-Y plane distance between the field point and the point on the cylinder at which the creeping wave leaves
SIRA	Dot product of cylinder unit normal and cylinder-scattered ray propagation direction unit vector
SMUIG	Parameter used in transition function
SNAG	Dot product of cylinder unit normal and vector from origin to source
SNF	Distance between last specular point on cylinder and near-field observation point
SS	Distance of path along the cylinder
SSS	Imaginary part of Fresnel integral (from subroutine FRNELS)
STA	Elliptical angle defining the source tangent point x-y location
THIR	Theta component of propagation direction of ray incident on cylinder

THSR1	Theta angle of D1
THSR2	Theta angle of D2
TTRN	Parameter used in transition function
TX1,TY1	X and Y components of unit vector of ray from source tangent to tangent point 1 of elliptic cylinder (2-D)
TX2,TY2	X and Y components of unit vector of ray from source tangent to tangent point 2 of elliptic cylinder (2-D)
UD	X,Y components of unit vector tangent to cylinder at tangent point (2-D)
UN	X,Y components of unit normal to cylinder at tangent point (2-D)
VD	Computational variable
VDP	Computational variable
VI	Elliptical angle used to define tangent points (2-D)
VIMAX	Maximum of VI(1) and VI(2)
VIMIN	Minimum of VI(1) and VI(2)
VJ	Elliptical angles defining the two tangent points on the cylinder for the vector from the field point tangent to the cylinder. Dimensioned two
VJD	The elliptical angle defining the x-y plane point on the cylinder at which the creeping wave leaves the cylinder
VL	Elliptical angle defining point where creeping wave meets cylinder
VU	Elliptical angle defining point where creeping wave leaves cylinder
XD,YD,ZD	X,Y,Z components of direction of ray from source to cylinder tangent point (incident ray for creeping and grazing incidence cases)

XI,YI,ZI	X,Y,Z components of point where incident creeping wave (or grazing wave) meets cylinder
XPT	X,Y,Z components of point where creeping wave begins on cylinder
XRF	X,Y,Z components of point where creeping wave leaves cylinder
XX	Parameter used in transition function
XXS	Parameter used in transition function
XXX	Limit of integration for Fresnel integral

5. **I/O VARIABLES:**

A. INPUT

INPUT	LOCATION
A	/GEOMEL/
AS	/GTD/
B	/GEOMEL/
BTS	/BNDSCL/
CJ	/COMP/
CPI4	/COMP/
CPS	/DIR/
CTC	/GEOMEL/
CTHS	/DIR/
D	/DIR/
DTS	/BNDSCL/
ENPH	/FUDG/
ENTH	/FUDG/
ESPH	/FUDG/
ESTH	/FUDG/

FLDPT	/WEAR/
IBG	/GTD/
LDEBUG	/TEST/
LWRFLD	/WEAR/
LRFC	/CLRFC/
LTRF	/FUDG/
LUPRNT	/ADEBUG/
PHSA	/DIR/
PI	/PIS/
RND1	/FUDG/
RG	/FUDG/
SAS	/GTD/
SWAG	/FUDG/
SPS	/DIR/
STHS	/DIR/
THSA	/DIR/
TPI	/PIS/
TRAN	/FUDG/
VTS	/RNDSCL/
VRS	/SGRINF/
XR	/FUDG/
XS	/SGRINF/
ZC	/GEOREL/

B. OUTPUT LOCATION

EP	F.P.
ERP	F.P.
ERT	F.P.
ET	F.P.

6. CALLING ROUTINE:

GTDDRV

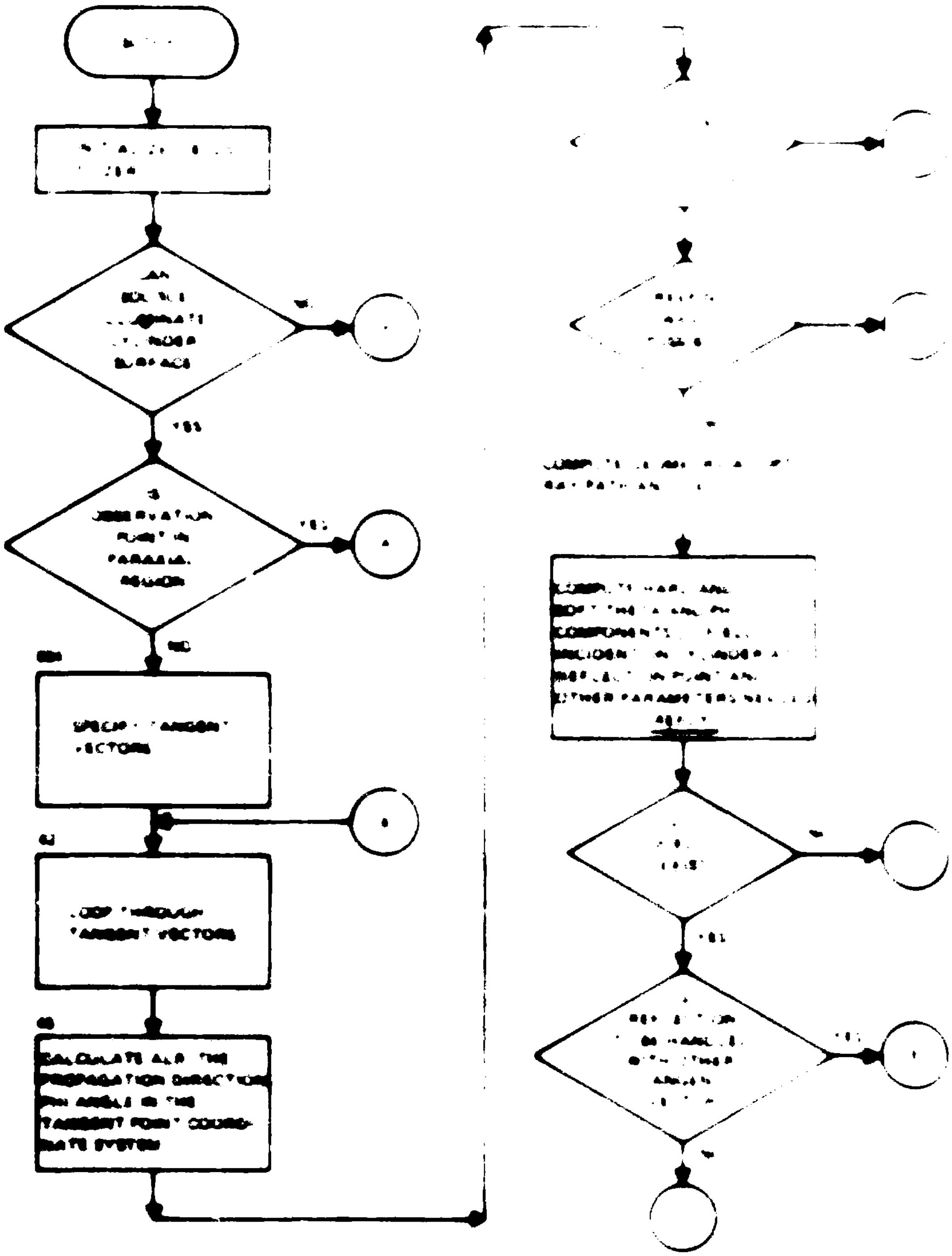
7. CALLED ROUTINES:

ASSIGN	QFUN
BEXP	RADCV
DTANP	REFCVL
DQB32	SHADWF
FCT	SOURCE
FUANG	STATIN
FUNELS	STATOT
HANKB	TANG
INFO	ULABCX
PFUN	XYZFLD
PLAINT	

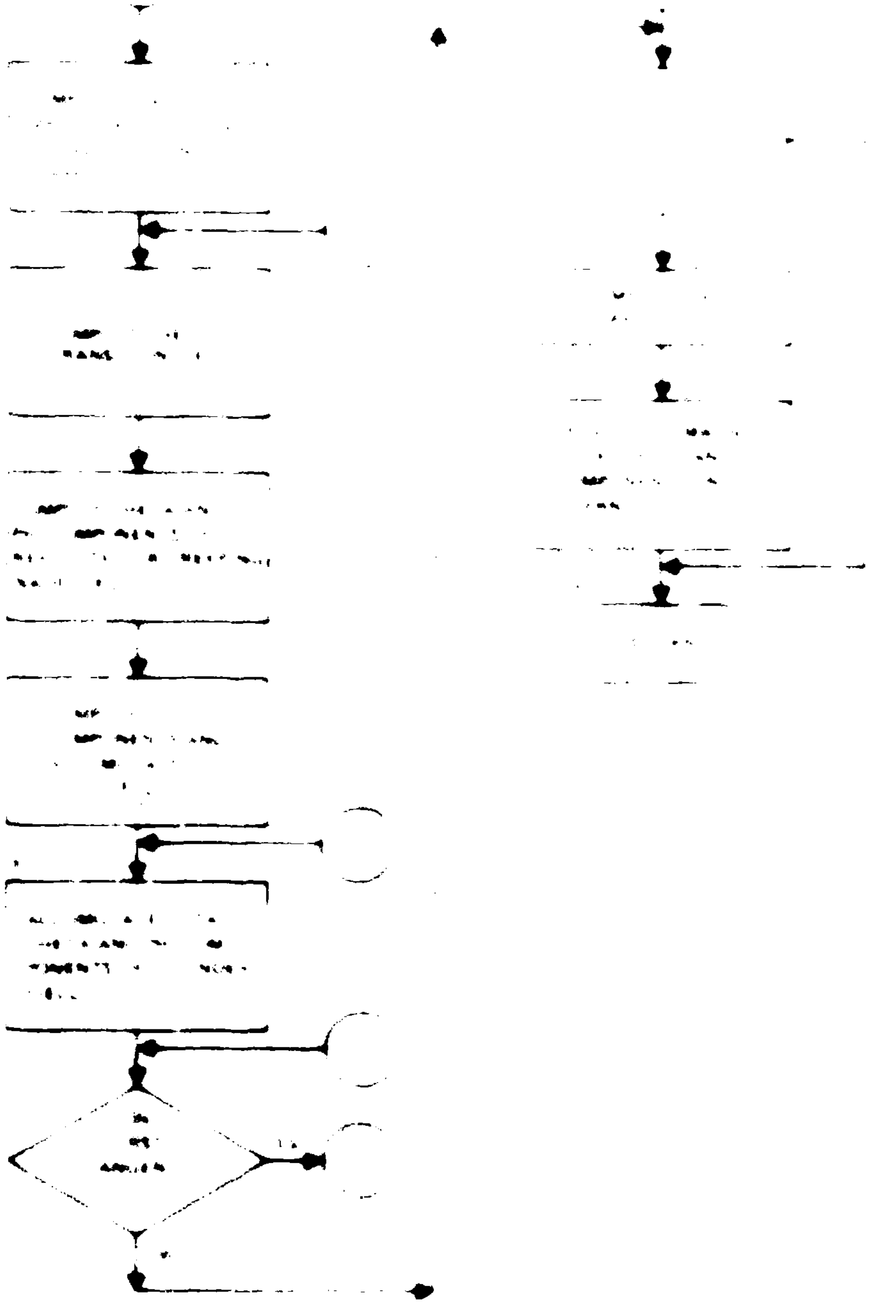
8. REFERENCES:

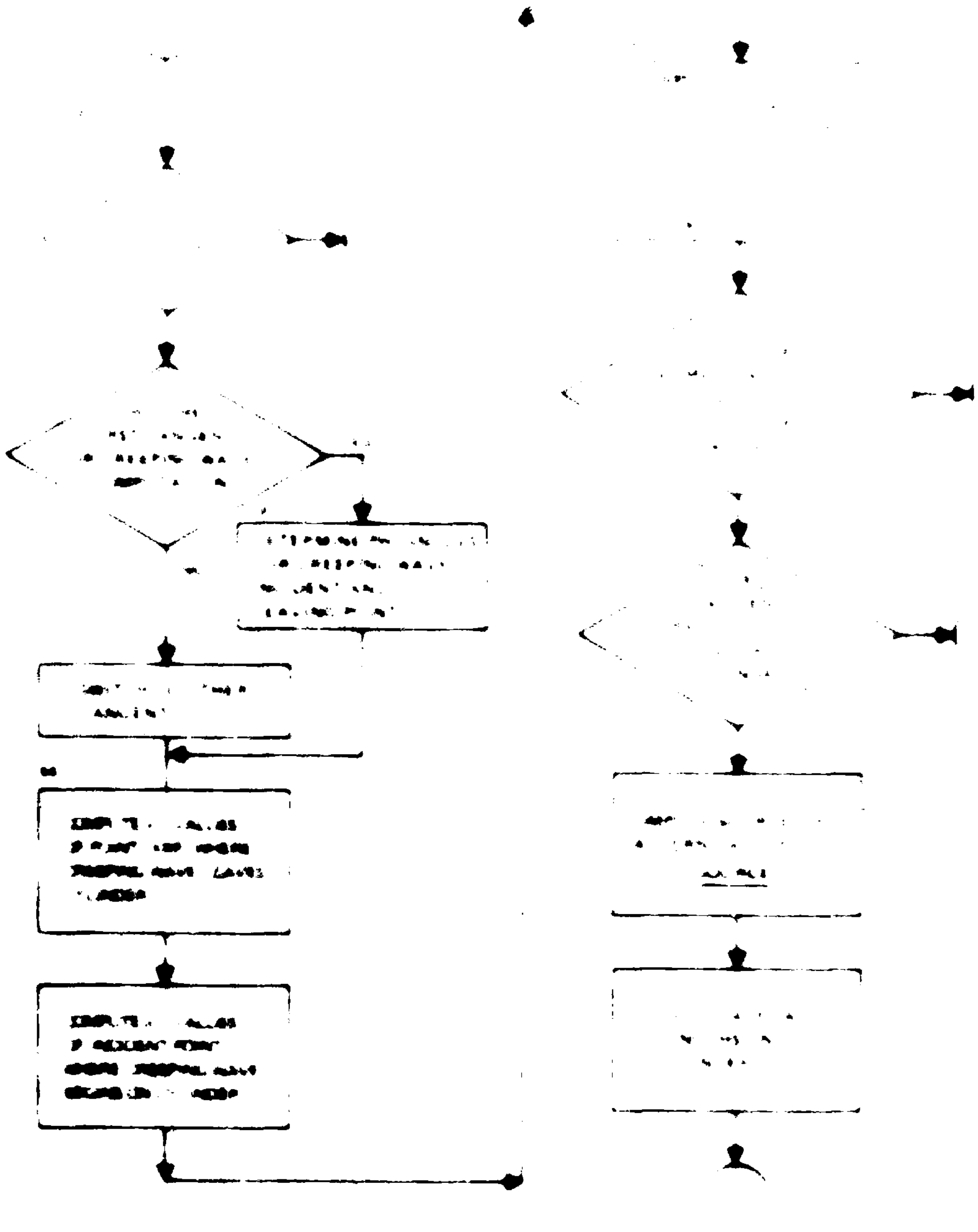
A. P. H. Pathak, W. D. Burnside and R. J. Marhefka, "A Uniform GTD Analysis of the Diffraction of Electromagnetic Waves by a Smooth Convex Surface," submitted for publication to IEEE Trans. on Antennas and Propagation. (Also report 784583-4, April 1979, The Ohio State University ElectroScience Laboratory, Department of Electrical Engineering; prepared under Contract No. N62269-76-C-0554 for Naval Air Development Center.

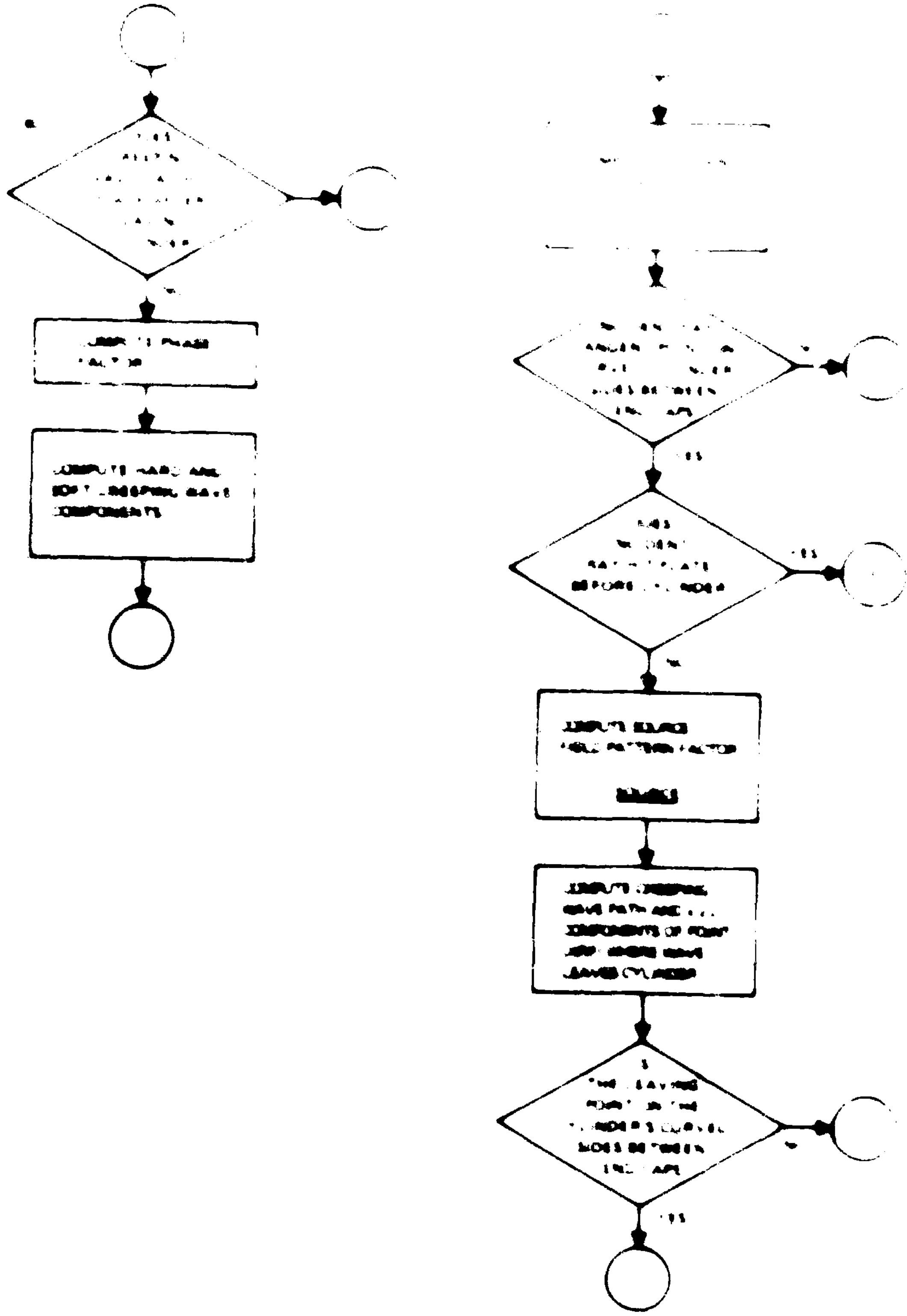
8. R. J. Marhefka, "Analysis of Aircraft Wing-Mounted Antenna Patterns," Report 2902-25, June 1976, The Ohio State University ElectroScience Laboratory, Department of Electrical Engineering; prepared under Grant No. NGL 36-008-138 for National Aeronautics and Space Administration.

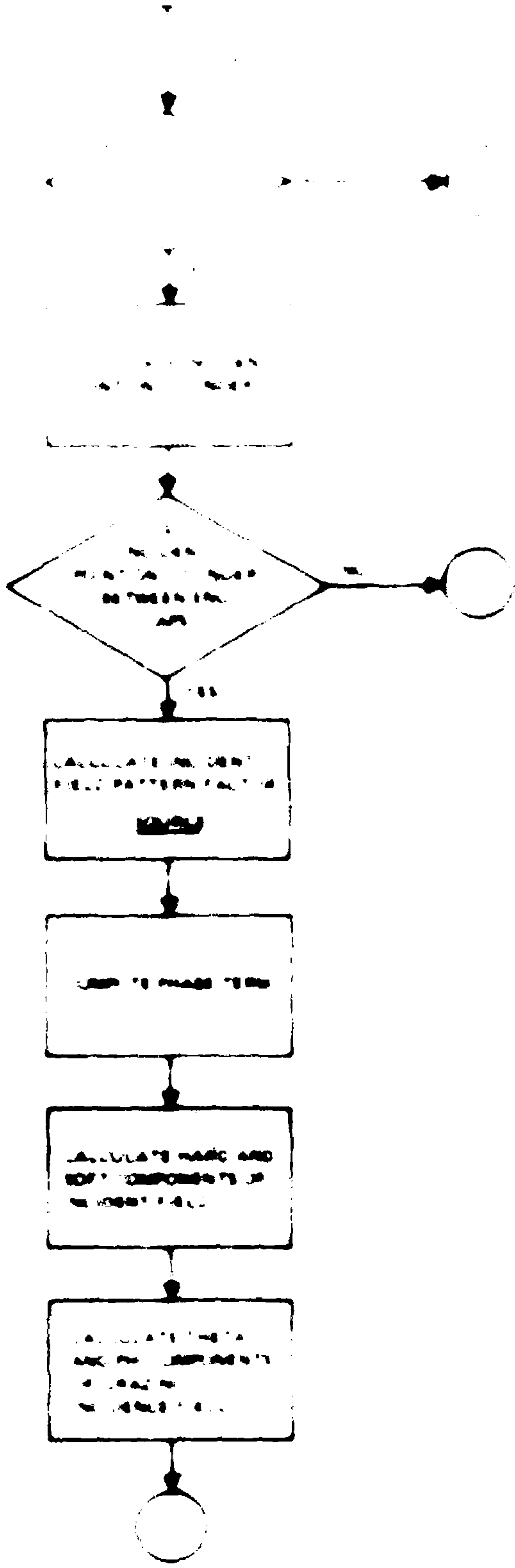


SURFACE
YES
NO
SPECIFY TANGENT VECTORS
LOOP THROUGH TANGENT VECTORS
CALCULATE ALL THE PROPAGATION DIRECTION
ANGLE IN THE TANGENT POINT COORDINATE SYSTEM
YES









1. NAME: SEGCON GTD, NUM

2. PURPOSE: To fill the segment connection data common area and compute the interpolation length for the current basis function.

3. METHOD: For a wire source, the coordinates of the wire needed for the interaction matrix generator are retrieved from the SEGTBL array. The connection data for the given source segment are then retrieved from the [illegible] associated with the wire segment from array SEGTBL. The interpolation lengths are then computed as the average distance from the end points of segments connected to the end of the source segment. The data are computed for both ends of the source segment. For a patch source, the coordinates of the patch, the orientation of the unit vectors $\hat{t}_1$ and $\hat{t}_2$, and the patch areas are retrieved from the SEGTBL array. For a non-source call, control is transferred to FORTRAN statement 100 and the coordinates, orientation and connection parameters of a wire segment are retrieved from the SEGTBL array and loaded into the common area ANPZIJ. However, for a patch observation segment the patch center point and the orientation of the unit vectors $\hat{t}_1$ and $\hat{t}_2$ are loaded into the common area ANPZIJ.

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
AREA	Surface area of a patch
B	Wire radius of source segment
CABI	Observation segment unit vector in the x direction
CABJ	Source segment unit vector in the x direction
DIK	Wire length from center of segment to center of following segment
DIL	Wire length from center of segment to center of preceding segment
FNCON	Number of data segments connected to either end of the source segment
IBLK	Data block index
ICON	Connection data for wire observation segment

ICON1	Pointer to the next segment connected to end 1 of the source segment
ICON2	Pointer to the next segment connected to end 2 of the source segment
ICO1	Pointer to the next segment connected to end 1 of the observation segment
ICO2	Pointer to the next segment connected to end 2 of the observation segment
IERROR	Error flag
INDX	Segment number for simple junction
ISGOBT	Observation segment number
ISGTBL	Array containing segment information
ITYP	Input argument designating [illegible]
J	Location of source segment within data block
JBIAS1	An integer to bias connection data to indicate end one is connected to source segment
JBIAS2	An integer to bias connection data to indicate end two is connected to source segment
JBIAS3	An integer to indicate connection of wire segment to a patch
JBLK	The data block where desired source segment is located
JCON	Segment connection data word for source segment
JCO1	Pointer to next segment connected to end 1 of the source segment
JCO2	Pointer to next segment connected to end 2 of the source segment
JIX	Array containing numbers of the segments which have end 1 connected to end 1 of the source segment

JI2	Array containing the integer values of the segments which have end 2 connected to end 1 of the source segment
JO1	Array containing the numbers of the segments which have end 2 connected to end 1 of the source segment
JO2	Array containing the identification of the segments which have end 2 connected to end 2 of the source segment
JSEG	Input argument designating segment number to be retrieved
JSGMNT	Segment identification number of segment stored in the JSEG location of SEGTBL array
LIMMVR	Same as JSEG
MAXCON	Maximum number of connections allowed
MAXSEG	Maximum number of segments per data block
NALJNC	Integer representation of FNCON
NCI1	Integer value of the number of segments which have end 1 connected to end 1 of the source segment
NCI2	Integer value of the number of segments which have end 1 connected to end 2 of the source segment
NCO1	Integer value of the number of segments which have end 2 connected to end 1 of the source segment
NCO2	Integer value of the number of segments which have end 2 connected to end 2 of the source segment
NOWBLK	Data block currently in use
NUMSEG	Total number of wire and patch data segments
NWIRE	Total number of wire segments

S	Wire segment length
SABI	Observation segment unit vector in the β direction
SABJ	Source segment unit vector in the β direction
SALPI	Observation segment unit vector in the α direction
SALPJ	Source segment unit vector in the α direction
SEGTBL	Array containing segment information, equivalent to SGTBL
SJ1	If negative, flag indicating multiple junction at end 1 of source segment; if zero, flag indicating a simple junction at end 1 of source segment
SJ2	Same as variable SJ1 for end 2 of source segment
SMC	Total length of segments connected to end of source segment
T1XI,T1YI,T1ZI	X,Y, and Z components of t_1 unit vector for the observation patch
T1XJ,T1YJ,T1ZJ	X,Y, and Z components of t_1 unit vector for the source patch
T2XI,T2YI,T2ZI	X,Y, and Z components of t_2 unit vector for the observation patch
T2XJ,T2YJ,T2ZJ	X,Y, and Z components of t_2 unit vectors for the source patch
XI,YI,ZI	X,Y, and Z components of center point of wire or patch observation point
XJ,YJ,ZJ	X,Y, and Z components of center point of wire or patch source point

5. I/O VARIABLES:

A. INPUT — LOCATION

INPUT	LOCATION
DBGPRT	/ADEBUG/
IP21?	/GEODAT/
ISGTBL	/SEGINT/
ISOFF	/ADEBUG/
ISON	/ADEBUG/
ITYP	F.P
JBIAS1	/SEGINT/
JBIAS2	/SEGINT/
JBIAS3	/SEGINT/
JSEG	F.P.
LUPRNT	/ADEBUG/
MAXCON	/JUNCON/
MAXSEG	/SEGINT/
NDMBLK	/SEGINT/
NUMSEG	/SEGINT/
NWIRE	/SEGINT/
SEGTBL	/SEGINT/

B. OUTPUT — LOCATION

OUTPUT	LOCATION
AMBDK	/AMBM/
AMBDL	/AMBM/
AREA	/AMP21J/
B	/AMP21J/
CABI	/AMP21J/

CABJ	AMP
DIR	AMP
DIC	AMP
ICO1	AMP
ICO2	AMP
IERROR	AUX BUG
JCO1	AMP
JCO2	AMP
JIR	JUNK [illegible]
JIZ	JUNK [illegible]
JOR	JUNK [illegible]
JOZ	JUNK [illegible]
JSEG	[illegible]
MCIR	JUNK [illegible]
MCIZ	JUNK [illegible]
MCOR	JUNK [illegible]
MCOZ	JUNK [illegible]
S	AMP
SABI	AMP
SABJ	AMP
SALPI	AMP
SALPJ	AMP
T1XI,T1YI,T1ZI	AMP
T1XJ,T1YJ,T1ZJ	AMP
T2XI,T2YI,T2ZI	AMP
T2XJ,T2YJ,T2ZJ	AMP

XI,YI,ZI AMP(I)

XJ,YJ,ZJ AMP(J)

6. CALLING ROUTINES:*

CADC (3)

ZGTDRV (2)

ZIJSET (3)

7. CALLED ROUTINES:

ASSIGN

ERROR

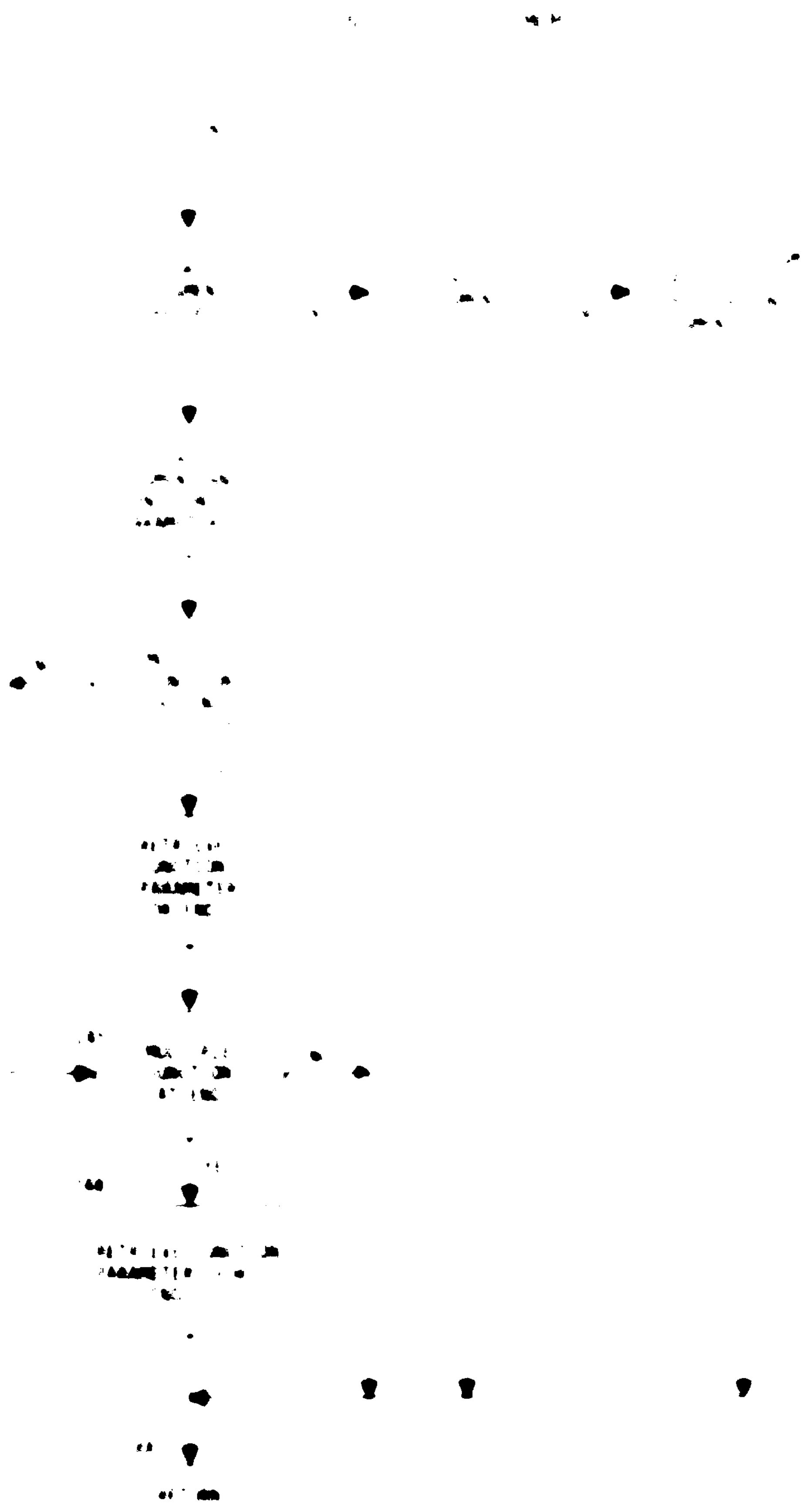
GETSEG

STATIN

STATOT

WLKBCK

* 2 GTD
3 NOM



.044

NAME

2 PURPOSE ... the (K,J) ... the SETIN command found ...

3 METHOD ... along with the ... interaction ... The argument LIST is examined for each of the keywords ... When found the corresponding ... available word of the KJIN array ... the leftmost portion, and the ... the rightmost portion. When the search is complete ... added as the last entry of KJIN to terminate the interaction list. Any extraneous or erroneous data of the SETIN command are ignored.

Some keywords indicate more than one (K,J) interaction ... For example, ... covers the (K,J) ... 4 ... 6 and ... When a keyword ... encountered, ... interactions are placed sequentially in KJIN. This is accomplished by use of the STOP LIST ... of SETIB. When a keyword is found that matches an SETIB keyword, the (K,J) interactions ... keywords up to, but not including, the keyword pointed to by the STOP LIST index are placed in KJIN. The ... ignored. For the ... keyword, the STOP ... index is 9. Therefore, (K,J) interactions in SETIB rows 2,3,4,5,6, and 8 are placed in KJIN and the keyword search continues for the keyword in row 9 (CV). This algorithm ensures that the KJIN list will always be in numerical order and that no duplication will ...

The NEXT KW column of SETIB makes it easy to add an additional interaction to SETIN. For example, suppose the interaction (K,J) ... 8 were to be added with keyword ... The new keyword would be added in row 22

22 Keyword number (8) ...
23

The NEXT KW entry in row 8 would become 22, as shown

8 ... 22 ... 22

The default interaction is ... set by ...

ROW NUMBER	KEYWORD NUMBER					
[illegible]	30	[illegible]		[illegible]		
[illegible]	[illegible]	[illegible]		[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
4	26	[illegible]	[illegible]			
[illegible]	24	[illegible]	[illegible]	[illegible]		
6	[illegible]	[illegible]				
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
9	30	[illegible]				
[illegible]	4	[illegible]				
[illegible]	2[illegible]	[illegible]				
[illegible]	29	[illegible]				
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
4	[illegible]	[illegible]	[illegible]			
[illegible]	32	[illegible]	[illegible]	[illegible]		
6	33	[illegible]				
[illegible]	34	[illegible]	[illegible]	[illegible]		
8	[illegible]	[illegible]	9	[illegible]		
19	40	[illegible]	20	[illegible]		
20	38	[illegible]	[illegible]	[illegible]		
2[illegible]	39	[illegible]	[illegible]		[illegible]	
22	[illegible]		[illegible]			

Figure [illegible] The [illegible] Array for [illegible]

4 INTERNAL VARIABLES

VARIABLE	DESCRIPTION
[illegible]	Index over argument [illegible]
[illegible]	[illegible] array
ISET	Row number of keyword [illegible]
ISTOP	[illegible] keyword [illegible] be considered
[illegible]	[illegible]
[illegible]	[illegible] keyword number

1. NAME SETUP[illegible]

2. PURPOSE Subroutine [illegible]

3. METHOD The type [illegible] through [illegible] the subroutine [illegible] read [illegible] previously defined [illegible] corresponding [illegible] the variable [illegible] are different [illegible] requirements [illegible] are [illegible]

4. INTERNAL VARIABLES

VARIABLE	[illegible]
COMP[illegible]	internal variable [illegible]
[illegible]	imag part [illegible] of the variable [illegible]
IARG	index of the argument [illegible]
ICOMPLX	flag indicating [illegible] already been typed [illegible]
IC1	first column of variable [illegible] loaded
IC2	last column of variable [illegible] the loaded
INDX	location of variable [illegible] loaded [illegible] the NDATB array
IREAL	flag indicating that variable [illegible] loaded [illegible] integer array
IR1	first row of variable [illegible] loaded
IR2	last row of variable [illegible] loaded
NAMSYM	symbol name of the [illegible] loaded
NBITS	[illegible] bytes [illegible] the variable [illegible] be loaded
NCOLS	number of columns [illegible] the variable [illegible] be loaded

[illegible]

NE[illegible]	Number [illegible]
NEWSYM	A [illegible]
NPREC[illegible]	Number [illegible]
NROWS	Number [illegible]
REAL	A [illegible]
RW	[illegible]

5. [illegible] VARIABLES

A. INPUT [illegible]

FLTARG	ARGUM
INTARG	ARGUM
IPASS	ARGUM
ISOFF	ADEBUG
ISON	ADEBUG
KBCPLX	PARTAB
KBREAL	PARTAB
KOLBIT	PARTAB
KOLCOL	PARTAB
KOLNAM	PARTAB
KOLROW	PARTAB
LUPRNT	ADEBUG
NDATBL	PARTAB
NOPCOD	ADEBUG

NTEMPS	TEMPCX
NTECPT	ADEBUG

8 OUTPUT LOCATION

TERRF	ADEBUG
TEMP	TEMPO1

6 CALLING ROUTINE

TSKEQT

7 CALLED ROUTINES

ASSIGN	PUTSYM
CONVRT	STATIN
ERROR	STATOT
GETARG	SYMDEF
GETSYM	WLKBCK
IBITCH	

1. NAME: SHELL [illegible] (GTD, NPUT, NOM, OUTPUT)

2. PURPOSE: Subroutine to perform a shell sort.

3. METHOD: A shell sorting technique is used to generate an ordering array to be returned to the calling subroutine.

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
HI	Index of the upper shell being sorted
I	Index to the ordering array for the lower shell
IM	Index to the ordering array for the upper shell
ITEMS	List of items to be sorted passed through as calling argument
K	Maximum number of items in lower shell to be sorted
LO	Index to sort items in lower shell
LOC	Ordering array for sort passed through as calling argument
M	Increment between lower and upper shell
NITEMS	Total number of items to be sorted

5. I/O VARIABLES:

	A. INPUT	LOCATION
	ITEMS	C.P
	NITEMS	C.P
	B. OUTPUT	**LOCATION**
	LOC	C.P

6. CALLING ROUTINES*

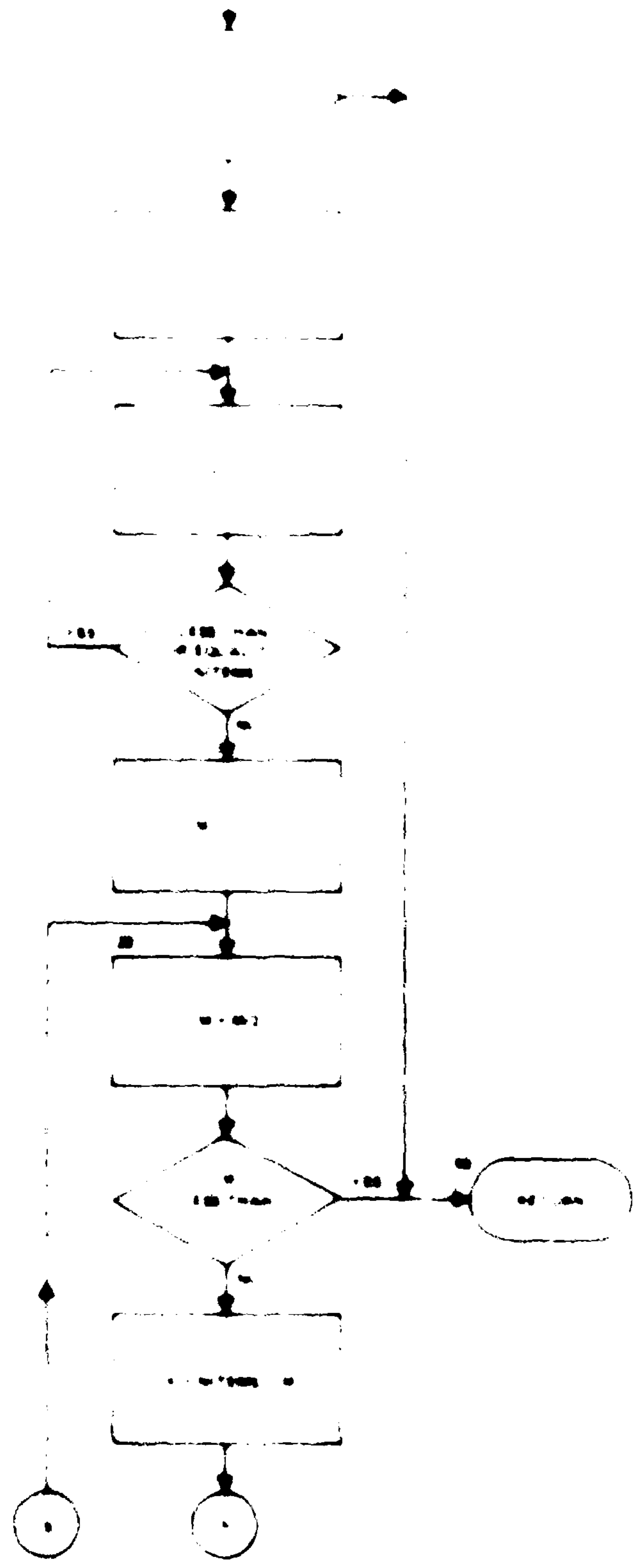
GENACS (1)

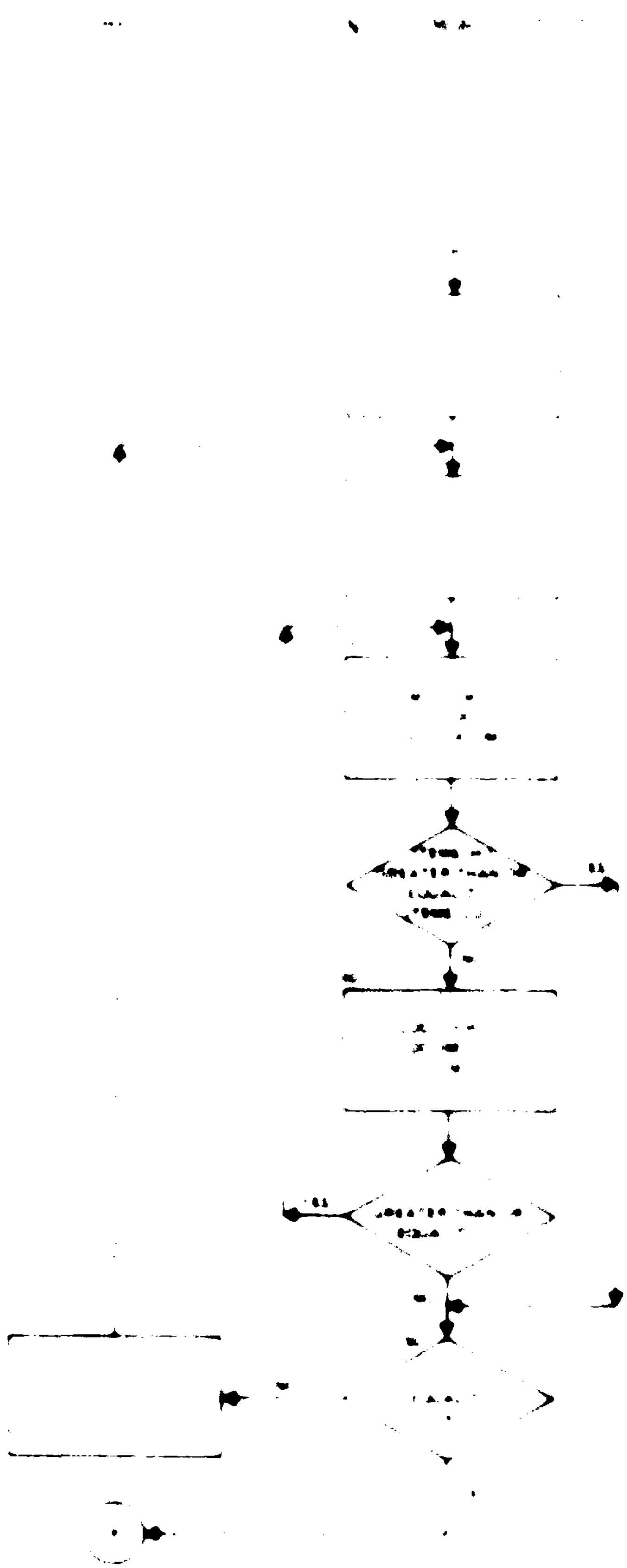
STATEN (1,2,3,4)

7. CALLED ROUTINES:

None

*1-INPUT
2-GTD
3-[illegible]
4-OUTPUT





1. NAME SHAGAM [illegible]

2. PURPOSE To compute the distance between two points.

3. METHOD Vector algebra is used to compute the distance.

4. INTERNAL VARIABLES

VARIABLE	DESCRIPTION
FLDPT	One of the two points from which the distance is computed [illegible] point
SAF	The distance
R	One of the two points from which the distance is computed [illegible] source [illegible] point

5. I/O VARIABLES

		LOCATION
A.	INPUT	LOCATION
	FLDPT	F.P.
	R	F.P.
B.	OUTPUT	LOCATION
	SAF	F.P.

6. CALLING ROUTINES

DIFPLT

DPLACL

DPLAPL

ENDIF

GTDORV

INCFLD

RCLDPL

SMALN

RC.RP.

REFCAP

REFCV.

REFPLA

RPLDP.

RPLRC.

RPLRP.

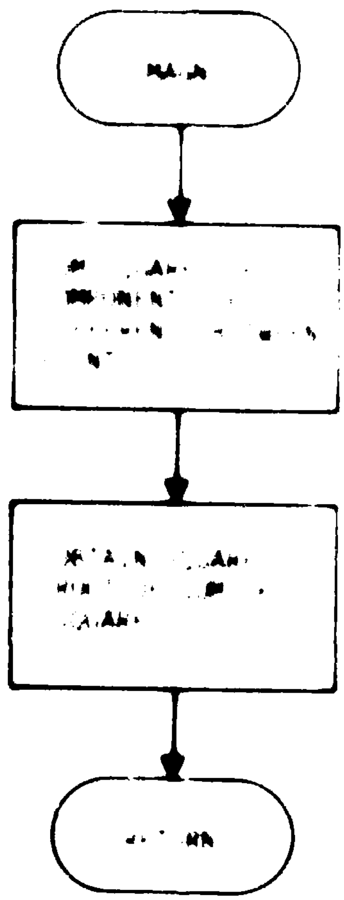
RPLSC.

SCLRP.

SCTCV.

CALLED ROUTINE

NONE



[illegible]

PURPOSE: [illegible]

METHOD: [illegible]

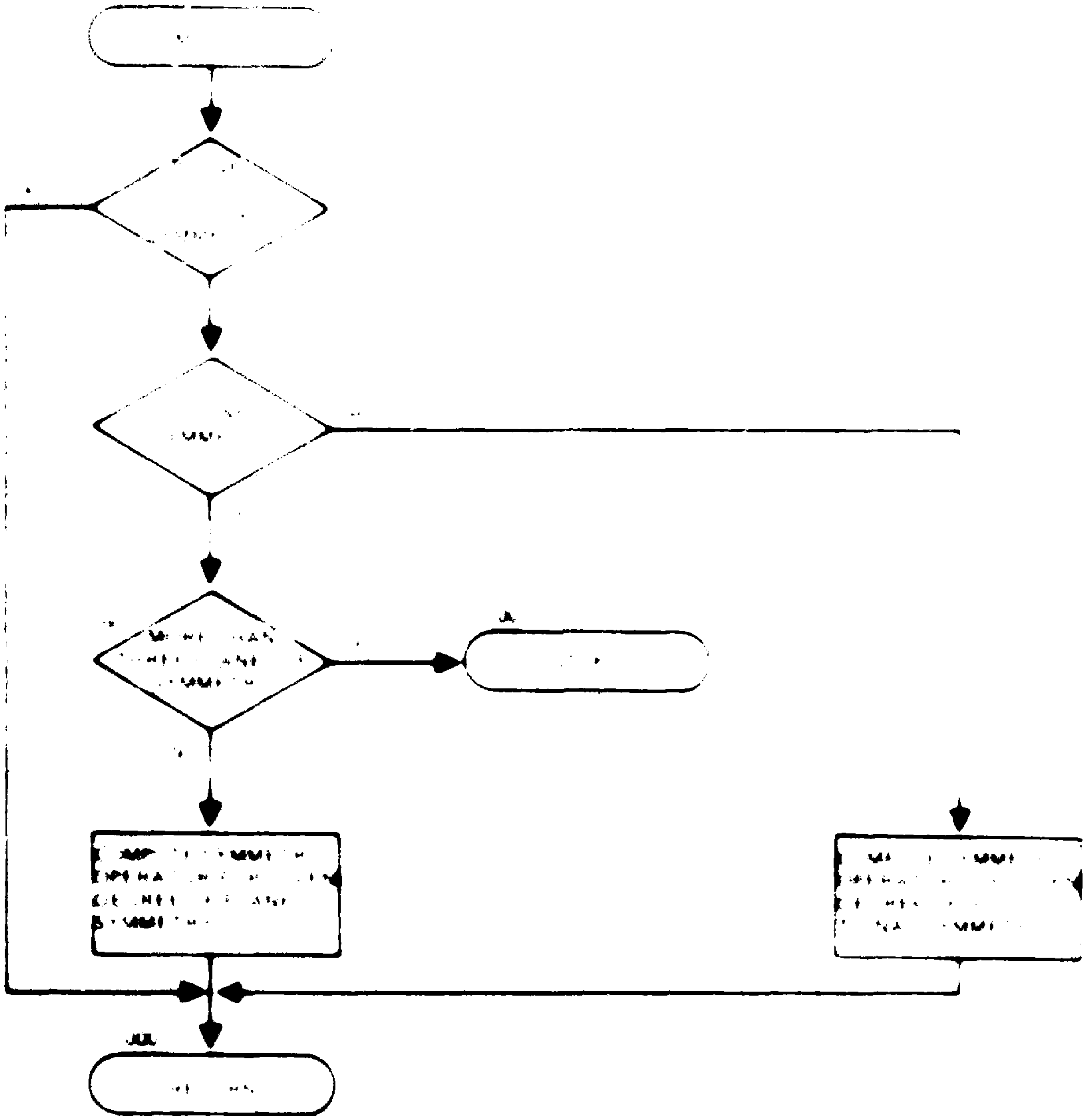
[illegible]

where N [illegible] the degree [illegible]

[illegible]

2. [illegible] orthogonal symmetry planes

3. Three orthogonal symmetry planes



NAME [illegible]

PURPOSE [illegible]

METHOD [illegible] number [illegible] arguments [illegible] indicates [illegible] RA [illegible] use of [illegible] the RA [illegible] hand side [illegible] table [illegible] number [illegible] table [illegible] table [illegible] the RMS [illegible]

use of [illegible] compute the RMS [illegible] convergence [illegible] iteration [illegible] computed [illegible] original [illegible] the decomposed [illegible] previous iteration [illegible] the RMS [illegible] computed [illegible] the RERR [illegible] tion before computing the [illegible] formulation

RERR [illegible]

RMS [illegible] RMS [illegible]

where [illegible]

[illegible]

[illegible] convergence [illegible]
and [illegible]
The convergence [illegible]
the iterat[illegible]
Otherwise, the [illegible]

[illegible] geometry [illegible]
returned [illegible]
array [illegible]
antenna parameter [illegible]
determined.

4 ANTENNA VARIABLES

VARIABLE [illegible]

[illegible]

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	Inverse of [illegible]
HEADR	[illegible] header [illegible] printed
IARG	Index of NIARG array
ICC	Convergence criteria index
ICOMPX	0 for complex system
INDXA	Index to the symbol table for A
INDXB	Index to [illegible] symbol table for B
INDXC	Index to the symbol table for C
INDXI	Index to the symbol table for I
INDXV	Index to the symbol table for V
IREAL	0 for real system
IREC1	First record index
IREC2	Last record index
ISTAT	0 for antenna source segment
KBAND	Attribute indicating banded matrix
LINKA	Index of the last symbol linked to A
LINKB	Index of the last symbol linked to B
LINKC	Index of the last symbol linked to C

[illegible]

[illegible]	Index of the [illegible]
[illegible]	Index of the [illegible]
[illegible]	[illegible]
[illegible]	[illegible] data set
[illegible]	[illegible] data set
LOC[illegible]	[illegible] the [illegible]
LOC[illegible]	[illegible]
LOC[illegible]	Pointer [illegible] array
LOC[illegible]	Index [illegible] data in [illegible] array
LOCRHS	Index [illegible] RHS [illegible] array
LOCSOL	Location of solution in [illegible] array
[illegible]	Predicted number of iterations required [illegible] convergence
MAXITR	Maximum number of iterations [illegible]
MINITR	Minimum number of iterations [illegible] performed before predicting the number of iterations needed for convergence
MORITR	Additional iterations required [illegible] convergence
NA	Output name for A
NACELL	Number of [illegible] for matrix storage
NAMARG	Hollerith argument names
NAMCVG	Hollerith convergence names
NAMEA	Name of symbol A
NAMEB	Name of symbol B
NAMEC	Name of symbol C
NAMEL	Name of load data
NAMEI	Name of symbol I

NAMEY	Name of ...
NB	Output name of B
NBIT	Attribute word of the data ... needed ...
NBITA	Attribute word for A
NBITB	Attribute word for B
NBITC	Attribute word for C
NBITE	Attribute word for E
NBITY	Attribute word for Y
NBNDWA	Bandwidth of A
NBMAT	Number of submatrices
NC	Output name of C
NCELLS	Number of cells for geometry
NCOLA	Number of columns in A
NCOLB	Number of columns in B
NCOLC	Number of columns in C
NCOLE	Number of columns in E
NCOLY	Number of columns in Y
NEED	Number of words needed in core
NG	Output name of the geometry data
NL	Output name of the load data
NLEFT	Amount of core left
NN, NNREC	Number of present submatrix
NPROLK	Number of columns in core at once
NPRCOL	Number of words per column
NPRELM	Number of words per element

NRECS	Number [illegible]
NROWA	Number [illegible]
NROWB	Number [illegible]
NROWC	Number [illegible]
NROWI	Number [illegible]
NROWV	Number [illegible]
NUMITR	Current iteration [illegible]
NUMMAT	NUMMA
NX	Output [illegible]
NY	Output [illegible]
NYRSYM	[illegible]
OLDBCR	[illegible]
OLDIRE	Old IRE
PREIRE	Predicted relative error
PREITR	Predicted iteration number [illegible]
PWRIN	Power into antenna
PWRLOS	Power loss in load
RELERR	Relative error
SOLIRE	Current IRE
SOLMAG	Solution magnitude
VLT	Antenna voltage
Z	Impedance
ZL	[illegible]
ZLODSQ	Load magnitude squared
ZMAG	Magnitude [illegible]

IOBRPT	ADEBUG
IOGTPRI	GEODAT
ARG	ARGCOM
IOTARG	ARGCOM
IOUKPT	SYSFIL
IOFILE	IOFILES
IOSCR1	SYSFIL
IOSCR2	SYSFIL
IPASS	ARGCOM
IP2	GEODAT
ISEG	SEGMNT
ISGTBL	SEGMNT
ISOFF	ADEBUG
ISON	ADEBUG
KBDAMC	PARTAB
KBCPT	PARTAB
KBGEOM	PARTAB
KBLOAD	PARTAB
KBREA	PARTAB

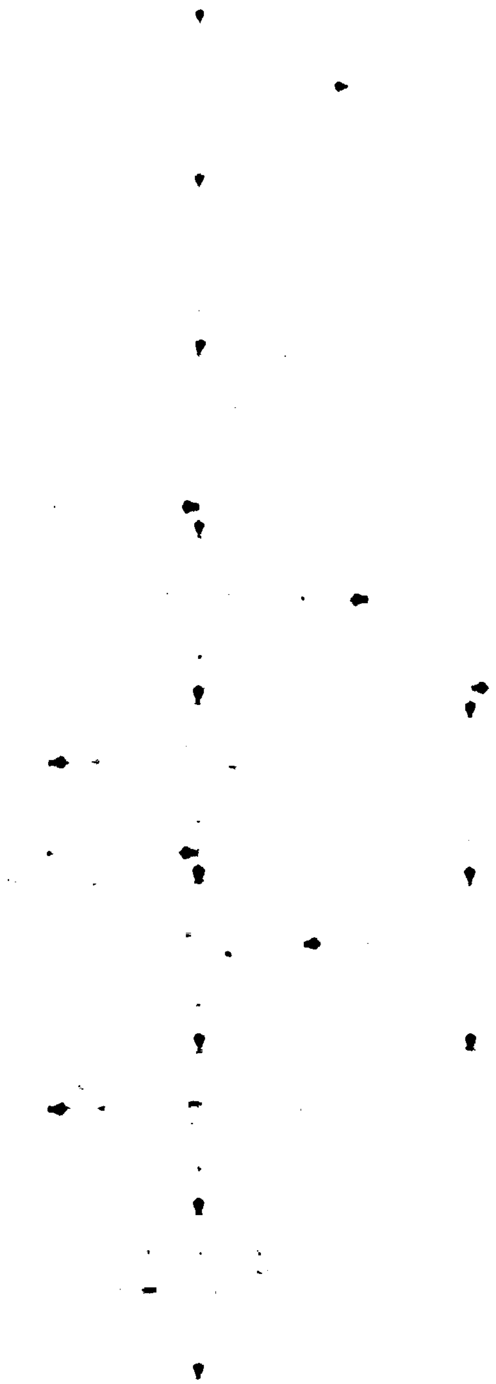
	KBSCAN	PARTAB
	KOLB	PARTAB
	KOLCOL	PARTAB
	KOLDIM	PARTAB
	KOLNAM	PARTAB
	KOLROW	PARTAB
	LPRNT	ADEBUG
	MAXBLK	SEGMNT
	NDATBL	PARTAB
	NDATRO	PARTAB
	NOPCDE	ADEBUG
	NPDATA	PARTAB
	NTEMPS	TEMPO1
	NTRLPT	ADEBUG
	NUMARG	ARGCOM
	NWIRE	SEGMNT
	SEGTBL	SEGMNT
	UPDBLK	SEGMNT
	ZERO	ADEBUG
B	OUTPUT	LOCATION
	IERROR	ADEBUG
	LOCKPT	SYSFIL
	NOGCFG	ADEBUG
	TEMP	TEMPO1

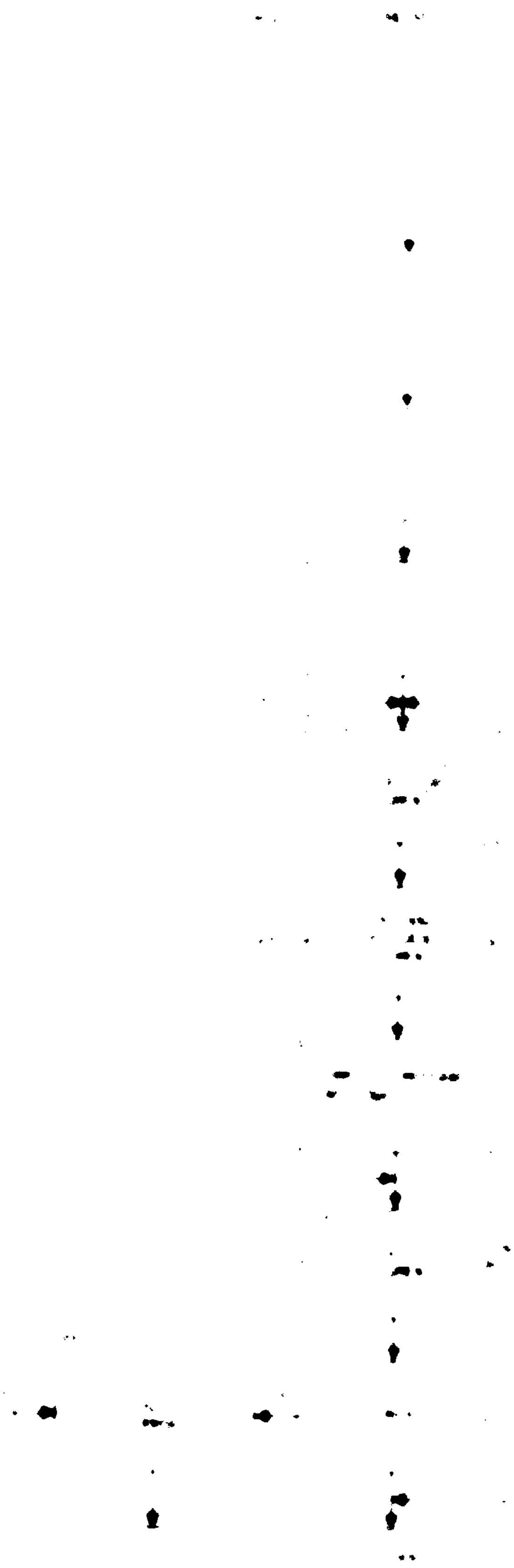
6 A [illegible]

[illegible]

A [illegible]

ASSIGN	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	





1. NAME [illegible]

2. PURPOSE [illegible]

3. METHOD [illegible] transposed [illegible] the [illegible] argument [illegible]

4. INTERNAL VARIABLES

VARIABLE	DEFINITION
A	[illegible] matrix
BANK	[illegible]
CIAG	The imaginary component of the [illegible] element [illegible] matrix
CIAGD	The real component of the diagonal element [illegible] matrices
DMAG	Magnitude of the diagonal element
[illegible] ISAV	[illegible] element [illegible]
INDX	FORTRAN [illegible] statement [illegible] the [illegible]
IORDER	Input argument [illegible] matrix
JSP	The last [illegible] the [illegible] substitution [illegible] the [illegible]
JST	The first [illegible] the [illegible] substitution [illegible] the [illegible]

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	The number of [illegible]
NP1	[illegible]
NC	Input argument [illegible] matrix A
NCOLS	Internal variable [illegible]
NR	[illegible]
NFRA[illegible]	Input argument, the number [illegible] element of A
NPRECN	Internal variable for NFRA
NR	Input argument, number [illegible]
NROWS	Internal variable for NR
REAL	Logical variable denoting a real matrix when TRUE
SUMI	The accumulated sum of the inner product [illegible] the imaginary term for a complex matrix
SUMR	The accumulated sum of the real part of the inner product for [illegible] matrices
TRANSP	Logical variable indicating a transposed matrix when TRUE
V	Input argument [illegible] containing the right hand side, returned as the [illegible]
VI	The imaginary part of the [illegible]
VR	The real part of the [illegible]

6. CALLING ROUTINE

BACSUB

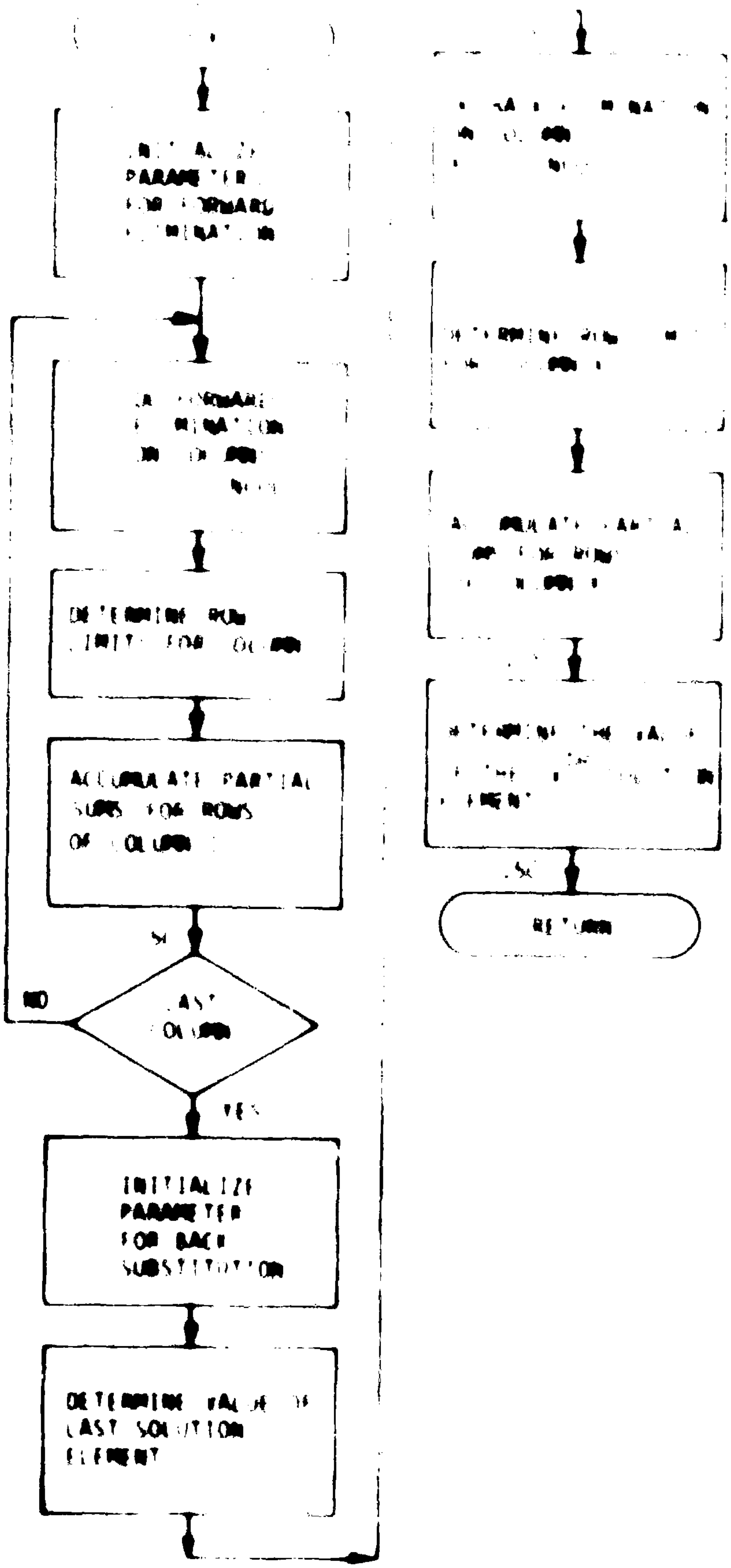
7. CALLED ROUTINES:

ASSIGN

STATIN

STATOT

WLKBCK



ACCUMULATE PARTIAL
SUMS FOR ROWS
OF COLUMN
NO
LAST
COLUMN
YES
INITIALIZE
PARAMETER
FOR BACK
SUBSTITUTION
DETERMINE VALUE OF
LAST SOLUTION
ELEMENT
RETURN

1084

1. NAME SOLVDH [illegible]

2. PURPOSE [illegible]

3. METHOD [illegible] accumulating the partial sums [illegible] perform the back substitution.

4. INTERNAL VARIABLES

VARIABLE	DEFINITION
A	Input argument [illegible]
BANC	[illegible]
COMPSI	[illegible]
DIAGI	The imaginary part of the diagonal element
DIAGM	The magnitude of the diagonal element
DIAGR	The real part of the diagonal element
IC1	Input argument designating first column of A in core
IC2	Input argument designating the last column of A in core
IFWD	Flag equal to zero for forward elimination, equal to one for back substitution
II	Index of the imaginary part of the solution vector
IR	Index of the real part of the solution vector
JB	Index of the column being used during back substitution

JK1 [illegible]

JK2 [illegible]

JK2ML [illegible]

JL [illegible]

JN [illegible]

JP [illegible]

JR [illegible]

K [illegible]

KP1 [illegible]

KP2 [illegible]

KSTART [illegible]

NC Input argument [illegible]

NCOLS Number [illegible]

NLAST The [illegible]

NPRATU Input argument [illegible] puter words per [illegible]

NPRELM Internal variable representing [illegible]

NR Input argument designating [illegible] rows [illegible]

NROWS The number [illegible]

NUMCOL Number [illegible]

NUMROW Number [illegible]

SR1 [illegible]

[illegible]

[illegible]	[illegible]
SOF [illegible]	ADE BUG,
SOR	ADE BUG,
[illegible]	[illegible]
BAC SUP [illegible]	

[illegible]

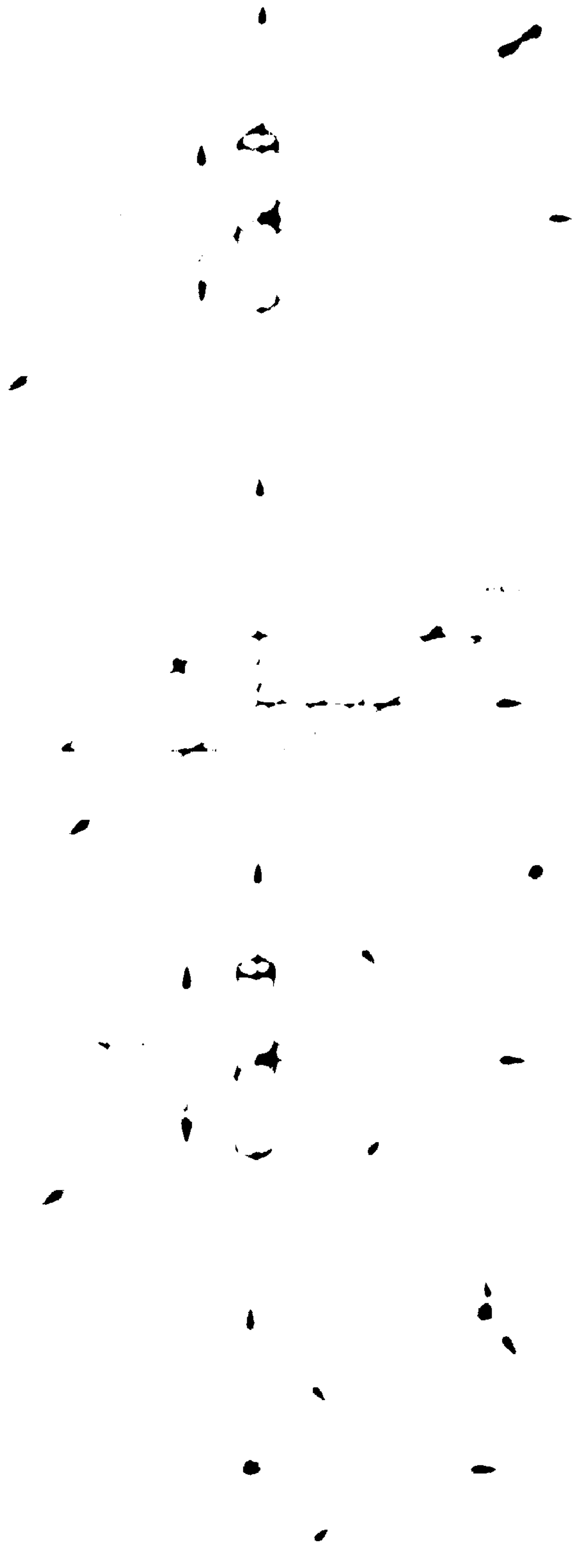
[illegible]

[illegible]

[illegible]

[illegible]

[illegible]



[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

TM... Pulse surface current on patch

Near field

where

Far field

$$H_\phi = \frac{\Delta}{4\pi} (jk) \; [illegible]$$

(M = 1 [illegible] dipole)

Far Field: (spherical coordinates)

$$E_\theta = \frac{j\omega\mu}{4\pi} \frac{e^{-jkr}}{r} \int_{-\Delta/2}^{\Delta/2} [illegible]$$

$$= \frac{j\eta I_0}{2\pi} \left[\frac{\cos\left(k\frac{\Delta}{2}\cos\theta\right) - \cos\left(k\frac{\Delta}{2}\right)}{\sin\theta} \right] [illegible]$$

(M = 2) Cylindrical wave — Not implemented

(M = 3) Spherical wave

Near Field: (spherical coordinates)

$$E_r = 0 \qquad E_\theta = [illegible] \; E_0 \frac{e^{-jkR}}{R} \qquad E_\phi = [illegible] \frac{e^{-jkR}}{R}$$

Far Field: (spherical coordinates)

$$E_r = 0$$

$$E_\theta = [illegible] \; E_0 \, e^{j\xi} \; [illegible] \left[\frac{e^{-jkr}}{r} \right]$$

$$E_\phi = [illegible] \; E_0 \, e^{j\xi} \; [illegible] \left[\frac{e^{-jkr}}{r} \right]$$

	ampere
	surface current amp meter
	wave number
	Magnitude
	Rectangular components
	Standard spherical coordinate system components
	Standard coordinate system components
	Distances point from ends of wire segment
	characteristic impedance of free space
	Angular frequency
	Permeability of free space
	Length of wire segment

where [illegible] and [illegible] are wave [illegible]
[illegible]

It should be noted that distances in SINWI have been [illegible] in wavelengths. Hence, SINWI returns fields in [illegible] per wavelength (near fields) or [illegible] (far fields). SINWI expects currents in amperes and current densities in amps/wavelength.

Two source parameters are used to pass geometry values to SINWI.

SP1 wire radius (wavelengths) or patch area (square wavelengths)

SP2 wire length (wavelengths)

4 INTERNAL VARIABLES

VARIABLE	DEFINITION
ACTHP	Absolute value of the cosine of [illegible] (source coordinate system)
BA	Wave number times wire radius
CDKZ	Wave number times wire half length times cosθ
CINT	Integral of cos(kr [illegible]) [illegible] over wire length (returned by ROMBRG)
CDIRC	Change in vector direction due to nonzero wire radius
CONST	Impedance of free space (376.7 ohms) divided by $8\pi^2$
CPH	Cosine of φ (RCS system)
CPHP	Cosine of φ (source coordinate system)
CR1	(π/2)·cos(kr [illegible]) [illegible] used in computing wire near fields
CR10	[illegible]
CR100	[illegible]
CR2	(π/2)·sin(kr [illegible]) [illegible] used in computing wire near fields

B2R	B2 [illegible]
B2RR	B2 [illegible]
S[illegible]	[illegible] of wave number [illegible] length
T[illegible]	[illegible] system
T[illegible]	[illegible] system
[illegible]K2	Wave number [illegible] length
D[illegible]	[illegible] between [illegible] and plane wave [illegible] less than [illegible], the [illegible] are said [illegible]
ER	Radial component of [illegible] cylindrical system
ERRC,ERIC	Real and imaginary components [illegible] cosine current distribution
ERRR,ERIR	Real and imaginary components of [illegible] pulse current distribution
ERRS,ERIS	Real and imaginary components [illegible] sine current distribution
EX,EY,EZ	Rectangular components of source [illegible] source coordinate system
EXRT1,EXIT1	Real and imaginary components of patch source near fields [illegible] component
EXPARG	Phase argument of plane wave
EX1	Angular dependence of dipole far fields
EYRT1,EYIT1	Real and imaginary components [illegible] patch source near fields [illegible] component
EZRC,EZIC	Real and imaginary components [illegible] cosine current distribution
EZRR,EZIR	Real and imaginary components [illegible] pulse current distribution

EZRS,EZIS	Real and imaginary [illegible] [illegible] current [illegible]
EZRT,EZIT	Real and imaginary components [illegible] source near [illegible] component
EARF	Theta component [illegible] reference coordinate system
EARG	Phi component [illegible] coordinate system
E1,E2,E3	Rectangular components [illegible] reference coordinate system
HP	Phi component of patch magnetic [illegible] source coordinate system
HT	Theta component of patch magnetic [illegible] source coordinate system
[illegible]	Internal variable [illegible] interactions are not to be [illegible]
IW	GTD source type
IPATCH	Flag indicating if the source is a patch or a wire segment
NRFLD	Flag indicating whether near [illegible] (NRFLD=1) or far fields [illegible] are to be evaluated
PW	Phase of plane wave at observation point
PWS	Phase of spherical wave at observation point
R	Source observation separation distance (wavelengths)
RIK	Wave number times distance from negative end of segment to observation [illegible]
RIKS	RIK*RIK
R2	R*R

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	Real and imag[illegible] parts [illegible]
[illegible]	Phase and spread [illegible] spher[illegible] wave near field[illegible]
[illegible]	Temporary storage [illegible] segment [illegible] and [illegible]
[illegible]	Real and imag[illegible] parts [illegible]

[illegible]

[illegible]

[illegible] [illegible]

[illegible] [illegible]
[illegible]

[illegible] [illegible]
[illegible]

[illegible] [illegible]
[illegible]

[illegible]
[illegible]
[illegible]

[illegible] [illegible]
[illegible]
[illegible]

[illegible] [illegible]
[illegible]

[illegible]
[illegible]

[illegible]

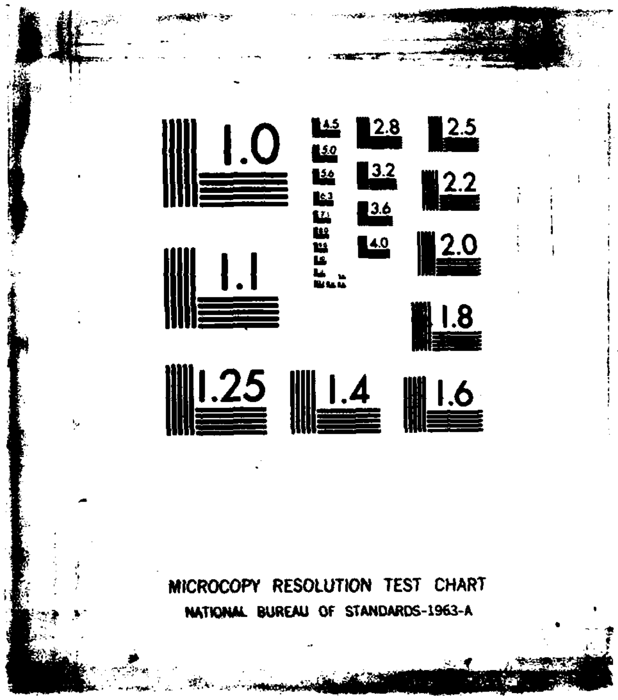
[illegible] [illegible]

[illegible]

[illegible]

AD-A137 509 GENERAL ELECTROMAGNETIC MODEL FOR THE ANALYSIS OF COMPLEX SYSTEMS (GEMACS..(U) BDM CORP ALBUQUERQUE NM D L KADLEC ET AL. SEP 83 BDM/A-83-020-TR-VOL-3-PT-3 4/5

UNCLASSIFIED RADC-TR-83-217-VOL-3-PT-3 F30602-81-C-0084 F/G 20/14 NL


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
5.6
6.3
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

SOURCE (GTD)

DPLRPL	REFCYL	RPLSCL
ENDIF	REFPLA	SCLRPL
INCFLD	RPLDPL	SCTCYL
RCLDPL		

CALLED ROUTINES:

ASSIGN

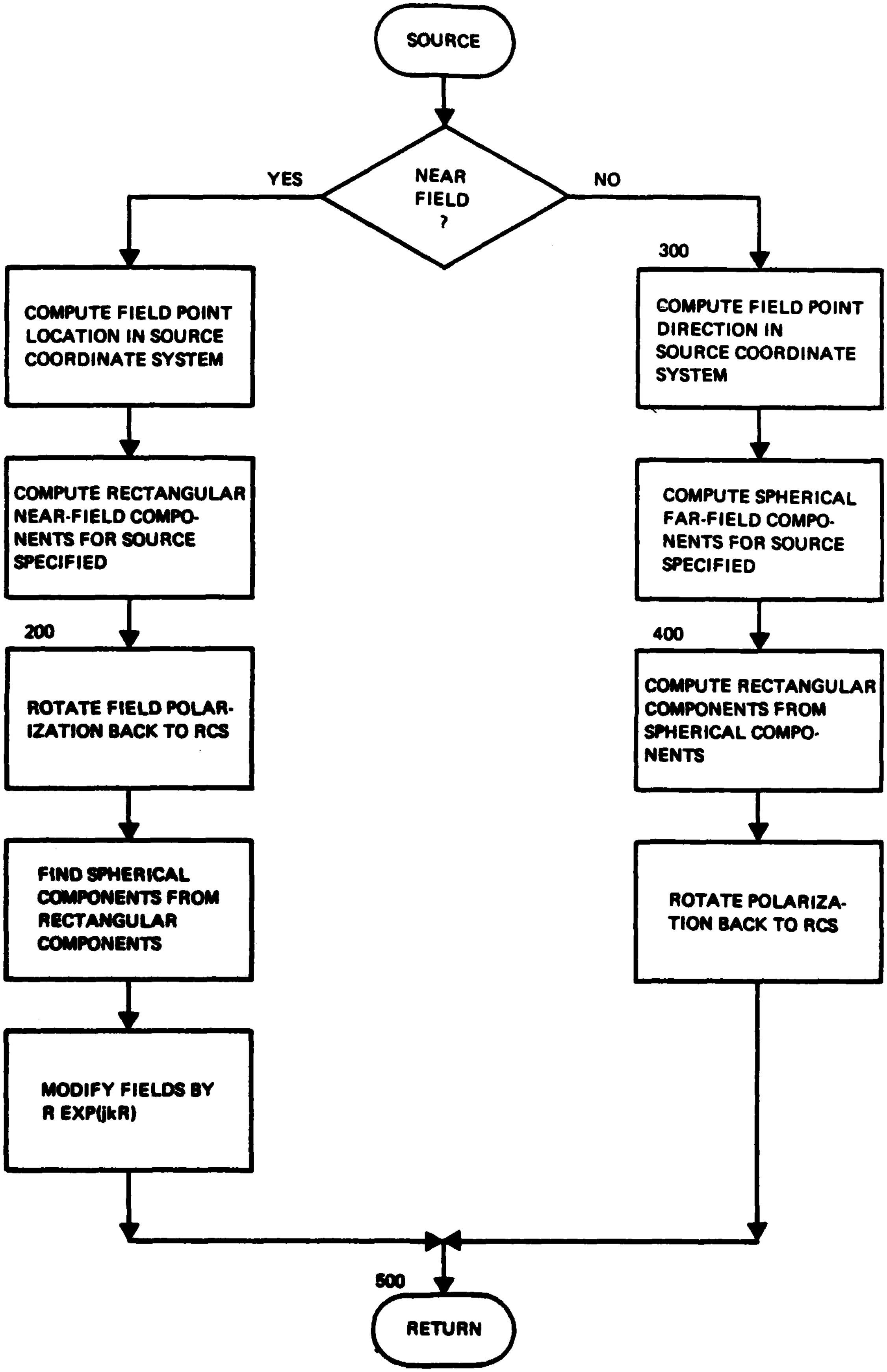
ROMBNT

STATIN

STATOT

WLKBCK

SOURCE (GTD)


SOURCE
NEAR FIELD ?
YES
NO
COMPUTE FIELD POINT LOCATION IN SOURCE COORDINATE SYSTEM
COMPUTE RECTANGULAR NEAR-FIELD COMPONENTS FOR SOURCE SPECIFIED
200
ROTATE FIELD POLARIZATION BACK TO RCS
FIND SPHERICAL COMPONENTS FROM RECTANGULAR COMPONENTS
MODIFY FIELDS BY R EXP(jkR)
300
COMPUTE FIELD POINT DIRECTION IN SOURCE COORDINATE SYSTEM
COMPUTE SPHERICAL FAR-FIELD COMPONENTS FOR SOURCE SPECIFIED
400
COMPUTE RECTANGULAR COMPONENTS FROM SPHERICAL COMPONENTS
ROTATE POLARIZATION BACK TO RCS
500
RETURN

1. NAME: SOURCP (GTD)

2. PURPOSE: To compute the tangential components of the normal derivative, $\frac{\partial E}{\partial n}$, of the incident field pattern factor for a source ray incident on a given edge.

3. METHOD: A source is located and oriented according to figure 1 and emits a ray incident on a diffracting edge. The slope field is given by

$$\frac{\partial \bar{E}}{\partial n} = \frac{1}{s' \sin \beta_o} \frac{\partial \bar{E}}{\partial \phi_o} \tag{1}$$

where

$$\bar{E} = \bar{E}_o(\theta', \phi') \frac{e^{-jks'}}{s'} \tag{2}$$

θ' and ϕ' are the spherical angles of the source ray in the source coordinate system. s' is the distance from the source to the edge.

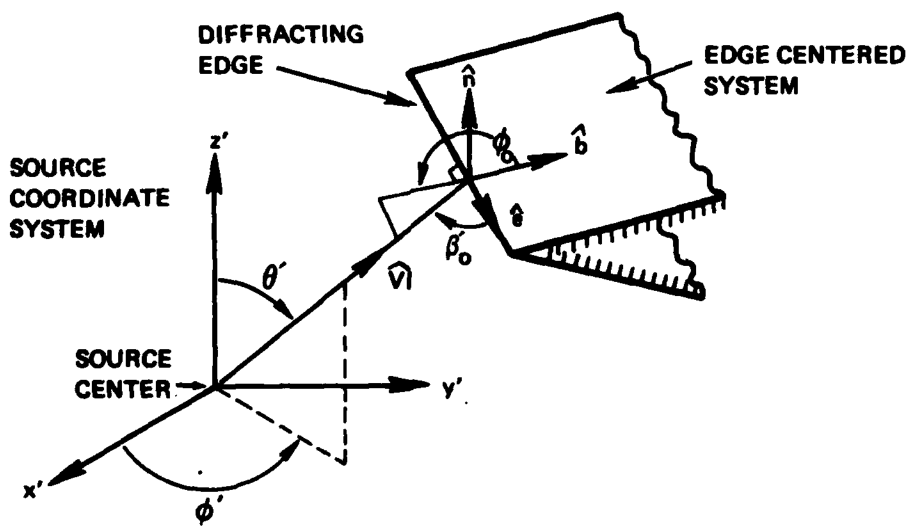


Figure 1. Pertinent Geometry for Slope Diffraction. The Unit Vectors $\hat{\theta}'$, $\hat{\phi}'$, $\hat{\beta}_o'$, and $\hat{\phi}_o$ Are Defined in the Standard Way.

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The required derivative in (1) is computed from the spherical components of the source field and their derivatives (in the source coordinate system) by using the chain rule of taking derivatives:

$$\frac{\partial \bar{E}}{\partial \phi_o} = \frac{\partial (E_\theta, \hat{\theta}')}{\partial \phi_o} + \frac{\partial (E_\phi, \hat{\phi}')}{\partial \phi_o} \tag{3}$$

$$= \hat{\theta}' \frac{\partial E_{\theta'}}{\partial \phi_o} + \underbrace{E_{\theta'}}_{\text{ET}} \frac{\partial \hat{\theta}'}{\partial \phi_o} + \hat{\phi}' \frac{\partial E_{\phi'}}{\partial \phi_o} + \underbrace{E_{\phi'}}_{\text{EP}} \frac{\partial \hat{\phi}'}{\partial \phi_o} \tag{4}$$

$$\frac{\partial E_{\theta'}}{\partial \phi_o} = \underbrace{\frac{\partial E_{\theta'}}{\partial \theta'}}_{\text{ETT}} \frac{\partial \theta'}{\partial \phi_o} + \underbrace{\frac{\partial E_{\theta'}}{\partial \phi'}}_{\text{ETP}} \frac{\partial \phi'}{\partial \phi_o} \tag{5}$$

$$\frac{\partial E_{\phi'}}{\partial \phi_o} = \underbrace{\frac{\partial E_{\phi'}}{\partial \theta'}}_{\text{EPT}} \frac{\partial \theta'}{\partial \phi_o} + \underbrace{\frac{\partial E_{\phi'}}{\partial \phi'}}_{\text{EPP}} \frac{\partial \phi'}{\partial \phi_o} \tag{6}$$

The angular derivatives are given by

$$\frac{\partial \theta'}{\partial \phi_o} = -\sin \beta_o' \underbrace{\hat{\phi}_o \cdot \hat{\theta}'}_{\text{TPHO}} \qquad \frac{\partial \phi'}{\partial \phi_o} = - \frac{\sin \beta_o'}{\sin \theta'} \underbrace{\hat{\phi}_o \cdot \hat{\phi}'}_{\text{PPHO}} \tag{7}$$

$$\frac{\partial \hat{\theta}'}{\partial \phi_o} = \sin \beta_o' \left[\underbrace{(\hat{\phi}_o \cdot \hat{\theta}')}_{\text{TPHO}} \underbrace{\hat{s}'}_{\text{VI}} - \cot\theta' \underbrace{(\hat{\phi}_o \cdot \hat{\phi}')}_{\text{PPHO}} \hat{\phi}' \right] \tag{8}$$

$$\frac{\partial \hat{\phi}'}{\partial \phi_o} = \frac{\sin \beta_o'}{\sin \theta'} \underbrace{(\hat{\phi}_o \cdot \hat{\phi}')}_{\text{PPHO}} \hat{\rho}' \tag{9}$$

$$\hat{\rho}' = \underbrace{\sin \theta'}_{\text{STHP}} \; \underbrace{\hat{s}'}_{\text{VI}} + \underbrace{\cos \theta' \; \hat{\theta}'}_{\text{CTHP}} \tag{10}$$

$$\hat{\theta}' = (\text{XTH, YTH, ZTH}) \tag{11}$$

$$\hat{\phi}' = (\text{XPH, YPH, ZPH}) \tag{12}$$

The above expressions may be combined to yield:

$$\frac{\partial \bar{E}}{\partial n} = \Bigg\{ \left[-\frac{\partial E_{\theta'}}{\partial \theta'} (\hat{\phi}_o \cdot \hat{\theta}')\, \hat{\theta}' - \frac{\partial E_{\phi'}}{\partial \theta'} (\hat{\phi}_o \cdot \hat{\theta}')\, \hat{\phi}' \right]$$

$$+ \frac{1}{\sin \theta'} \left[- \frac{\partial E_{\theta'}}{\partial \phi'} (\hat{\phi}_o \cdot \hat{\phi}')\, \hat{\theta}' - \frac{\partial E_{\phi'}}{\partial \phi'} (\hat{\phi}_o \cdot \hat{\phi}')\, \hat{\phi}' \right]$$

$$+ \cot \theta' \left[- E_{\theta'} (\hat{\phi}_o \cdot \hat{\phi}')\, \hat{\phi}' + E_{\phi'} (\hat{\phi}_o \cdot \hat{\phi}')\, \hat{\theta}' \right] \Bigg\} \frac{e^{-jks'}}{s'^2} \tag{13}$$

Note that $\sin \beta_o'$ is eliminated from the expression in (13). Also, only the tangential components are retained.

SOURCP returns the quantity within the brackets, as the term $\frac{e^{-jks'}}{s'^2}$ is added elsewhere in the code. The two field components EIPRP and EIPLP are given by:

$$\frac{\partial \bar{E}}{\partial n} = [\text{EIPRP } \hat{\phi}_o + \text{EIPLP } \hat{\beta}_o'] \frac{e^{-jks'}}{s'^2} \tag{14}$$

EIPRP is computed by taking the dot product of (13) with $\hat{\phi}_0$, ignoring the exponential term. EIPLP is obtained by dotting (13) with $\hat{\beta}'_0$.

Since $E_{\theta'}$ and $E_{\phi'}$ for GTD and MOM sources are analytic in the far field, it is straightforward to obtain the necessary partial derivatives. For example, consider a wire segment with pulse current (IM=1):

$$ET = E_{\theta'} = \frac{j\eta}{2}\left(\frac{\Delta\ell}{\lambda}\right)\sin\theta' \qquad EP = E_{\phi'} = 0$$

$$ETT = \frac{\partial E_{\theta'}}{\partial\theta'} = \frac{j\eta}{2}\left(\frac{\Delta\ell}{\lambda}\right)\cos\theta' \qquad EPT = \frac{\partial E_{\phi'}}{\partial\theta'} = 0$$

$$ETP = \frac{\partial E_{\theta'}}{\partial\phi'} = 0 \qquad EPP = \frac{\partial E_{\phi'}}{\partial\phi'} = 0 \tag{15}$$

These terms are then substituted into the formulas for EIPRP and EIPLP at statement 100.

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
ACTHP	Absolute value of the cosine of θ' (source coordinate system)
BOP	Rectangular components of the beta-component of the incident field in RCS system
CCDK2	Cosine of CDK2
CDK2	Wave number times wire half-length times cosine of θ'
CNDK2	Cosine of DK2
CONST	jη(½ℓ/λ)*λ used in computing patch slope fields
CPHP	Cosine of ϕ'(source coordinate system)
CTHP	Cosine of θ' (source coordinate system)

DK2	Wave number times wire half-length
E1,E2	Temporary storage for terms used to compute slope fields of stiff dipole source
EA,EB	Temporary storage for terms used to compute slope fields of stiff dipole source
EFA	Partial derivative of dipole pattern factor with respect to theta
EFB	Dipole pattern factor divided by sin(θ')
EIPLP	Parallel polarized component (soft) of normal derivative of incident fields (parallel to edge)
EIPRP	Perpendicularly polarized (hard) component of normal derivative of incident fields (perpendicular to edge)
EP	Phi polarized component of incident field (source coordinate system)
EPP	Partial derivative of EP with respect to phi
EPT	Partial derivative of EP with respect to theta
ET	Theta polarized component of incident field (source coordinate system)
ETP	Partial derivative of ET with respect to phi
ETT	Partial derivative of ET with respect to theta
IM	GTD source type
PHO	Rectangular components of the phi-component of the incident field in RCS
PPBO	Dot product of phi polarization unit vector of source coordinate system and beta polarization unit vector of edge-centered coordinate system

PPHO	Dot product of phi polarization unit vector of source coordinate system and phi polarization unit vector of edge-centered coordinate system
RDX	Projection of incident ray direction onto source x axis
RDY	Projection of incident ray direction onto source y axis
SCDK2	Sine of CDK2
SN	Sign of CTHP
SNDK2	Sine of DK2
SP1	Source parameter one: wire radius (wavelengths) or patch area (square wavelengths)
SP2	Source parameter two: wire length (wavelengths)
SPHP	Sine of ϕ' (source coordinate system)
STHP	Sine of θ' (source coordinate system)
TPBO	Dot product of theta polarization unit vector of source coordinate system and the beta polarization unit vector of edge-centered coordinate system
TPHO	Dot product of theta polarization unit vector of source coordinate system and the phi polarization unit vector of edge-centered coordinate system
VAX	Source axes direction cosines (RCS rectangular component projections)
VI	Direction cosines of incident ray propagation direction
XPH,YPH,ZPH	Rectangular components of the phi unit polarization unit vector in the source coordinate system (RCS components)
XTH,YTH,ZTH	Rectangular components of the theta unit polarization unit vector in the source coordinate system (RCS components)

5. I/O VARIABLES:

A. INPUT

INPUT	LOCATION
BOP	F.P.
CJ	/COMP/
ETA	/AMPZIJ/
IM	/SRC/
PHO	F.P.
PI	/PIS/
SP1	/SRC/
SP2	/SRC/
TPI	/PIS/
VAX	F.P.
VI	F.P.

B. OUTPUT

OUTPUT	LOCATION
EIPLP	F.P.
EIPRP	F.P.

6. CALLING ROUTINES:

DIFPLT

DPLRPL

RPLDPL

7. CALLED ROUTINES:

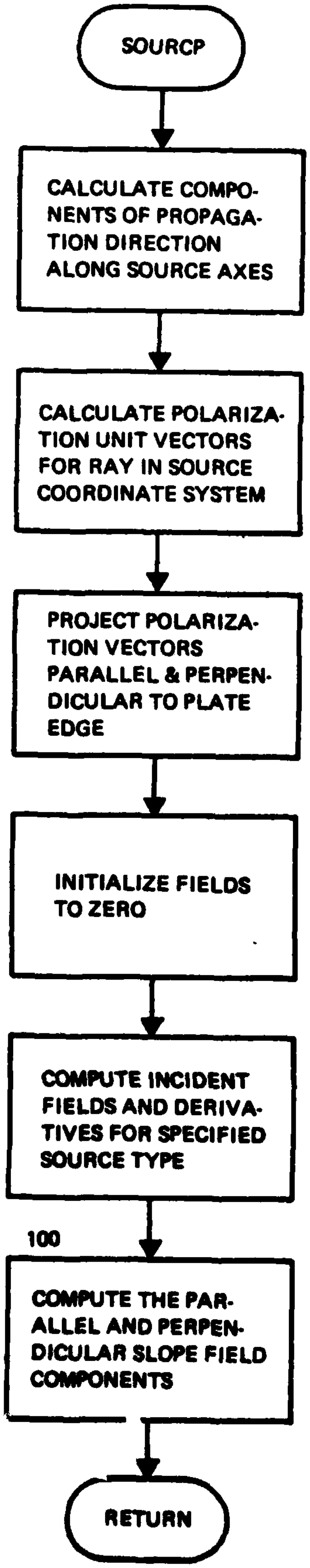
ASSIGN

STATIN

STATOT

WLKBCK

SOURCP (GTD)


SOURCP
CALCULATE COMPONENTS OF PROPAGATION DIRECTION ALONG SOURCE AXES
CALCULATE POLARIZATION UNIT VECTORS FOR RAY IN SOURCE COORDINATE SYSTEM
PROJECT POLARIZATION VECTORS PARALLEL & PERPENDICULAR TO PLATE EDGE
INITIALIZE FIELDS TO ZERO
COMPUTE INCIDENT FIELDS AND DERIVATIVES FOR SPECIFIED SOURCE TYPE
100
COMPUTE THE PARALLEL AND PERPENDICULAR SLOPE FIELD COMPONENTS
RETURN

1. NAME: SPWDRV (MOM)

2. PURPOSE: Generate the plane or spherical wave excitation on the structure.

3. METHOD: The coordinate system and parameters are illustrated in figure 1, where $\bar{E}$ is the linear component and $\overline{EP}$ is the polarization component of the incident electric field. The eccentricity ε specifies $|\overline{EP}|/|\bar{E}|$ and for positive ε, the wave vector $\bar{k}$ has direction given by $\bar{E} \times \overline{EP}$ for negative ε, the wave vector $\bar{k}$ has direction given by $\bar{E} \times \overline{EP}$ and for negative ε, $\bar{k}$ has direction given by $\overline{EP} \times \bar{E}$. For plane wave excitation, $\bar{k}$ is oriented toward the origin;

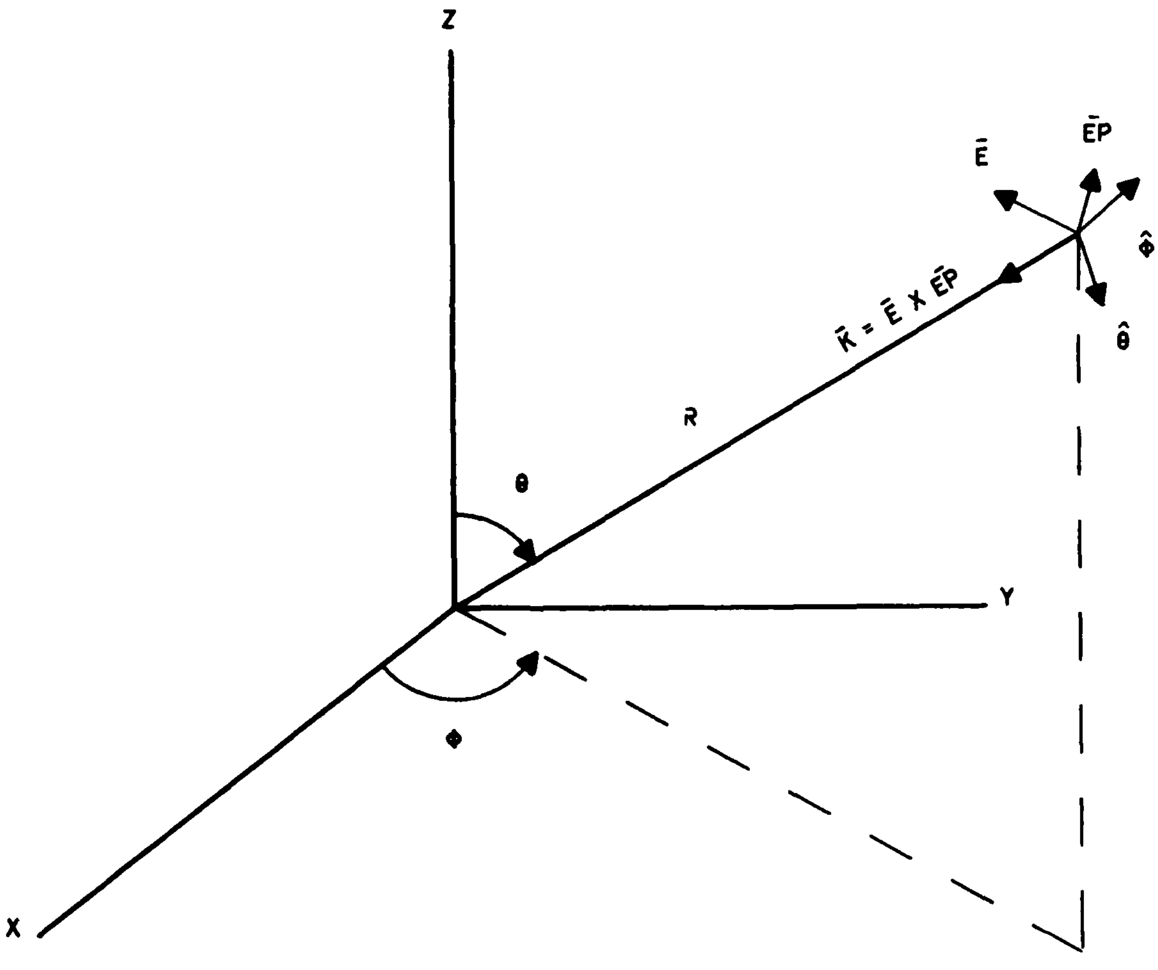


Figure 1. Geometry for Plane or Spherical Wave Excitation

whereas for spherical wave excitation, $\bar{k}$ is oriented toward the observation point. The total field is given by

$$\bar{E}^t = \bar{E}^I + \bar{E}^R$$

$$\bar{E}^I = \bar{E} + j\bar{E}\bar{P}$$

where $\bar{E}^R$ is the reflected field. $\bar{E}^R$ is given by:

$$\bar{E}^R = (\bar{E}^n_{\parallel} + \bar{E}^P_{\parallel})\ R_{\parallel} \ -\bar{E}_{\perp} R_{\perp}$$

where $\bar{E}^n_{\parallel}$ and $\bar{E}^P_{\parallel}$ are the components of the total field incident normal to (n) and parallel to (P) the reflective surface. $\bar{E}_{\perp}$ is the total incident field perpendicular to the plane of reflection. $R_{\parallel}$ and $R_{\perp}$ are the modified Fresnel reflection coefficients for the in-plane and out-of-plane components as described in the Engineering Manual.

The excitation for a segment located at $\bar{R}_i$ oriented parallel to $\bar{\ell}_i$ with length $|\bar{\ell}_i|$ is

$$E_i = -\bar{\ell}_i \cdot \bar{E}^t (R_i)$$

where

$$\bar{E}^t (R_i) = \bar{E}^I e^{-j\bar{k}_i \cdot \bar{R}_i} + \bar{E}^R e^{-j\bar{k}_r \cdot \bar{R}_i}$$

$$\bar{k}_i = \frac{2\pi}{\lambda} \hat{k}_i$$

$$\bar{k}_r = \frac{2\pi}{\lambda} \hat{k}_r$$

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
ARGI	$\frac{2\pi}{\lambda} \bar{k}_i \cdot \bar{R}_i$
ARGR	$\frac{2\pi}{\lambda} \bar{k}_i \cdot \bar{R}_i$
COSARG	Real component of $e^{-jk \cdot \bar{R}_i}$
COSETA	$(\bar{E} \cdot \hat{\phi})/\lvert\bar{E}\rvert$
COSP	Cosine of ϕ
COST	Cosine of θ
DXSW	X component of source with respect to specular point
DYSW	Y component of source with respect to specular point
DZSW	Z component of source with respect to specular point
ECCN = ECCEN	Eccentricity $(\lvert\overline{EP}\rvert/\lvert\bar{E}\rvert)$
EM	Magnitude $\lvert\bar{E}\rvert$
EPRX,EPRY,EPRZ	X,Y,Z components of reflected polarization component of incident wave
EPX,EPY,EPZ	X,Y,Z components of reflected linear component of incident wave
ERX, ERY, ERZ	X,Y,Z components of reflected linear component of incident wave
ESX,ESY,ESZ	X,Y,Z components of linear component of incident wave
ETAE	Angle between $\bar{E}$ and $\hat{\theta}$
ETAINV	1/377 (mho)
ETAP	Polarization angle
EXI	Total x component of incident wave

EXPARG	$e^{-jk \cdot \bar{R}_1}$
EXR	Total x component of reflected wave
EXRI	In-plane reflected x component
EXS	Linear x component
EYI	Total y component of incident wave
EYR	Total y component of reflected wave
EYR1	In-plane reflected y component
EYS	Linear y component
EZI	Total z component of incident wave
EZR	Total z component of reflected wave
EZRI	In-plane reflected z component
F	Logical .FALSE.
GROUND	Logical .TRUE. if ground present
HCNVRT	Logical .TRUE. if convert to H-field for plane wave
HXI,HYI,HZI	X,Y,Z components of incident H-field for patches
HXR,HYR,HZR	X,Y,Z components of reflected H-field for patches
KIX	$\bar{k}_1 \cdot \hat{X}$
KIXSQ	$(KIX)^2$
KIY	$\bar{k}_1 \cdot \hat{Y}$
KIYSQ	$(KIY)^2$
KIZ	$\bar{k}_i \cdot \hat{Z}$
KRX	$\bar{k}_1 \cdot \hat{X}$
KRXSQ	$(KRX)^2$

KRY	$\bar{k}_r \cdot \hat{y}$
KRYSQ	$(KRY)^2$
KRZ	$\bar{k}_r \cdot \hat{z}$
KSYMP	1 = no ground 2 = ground
KXKY	KIX * KIY
LBLK	Block number containing subsection being considered
LINEAR	.TRUE. for ECC = 0 .FALSE. for ECC > 0
NAMEXC	Symbolic name of excitation data set
NDXBLK	Block number of current geometry data
NI	Index to TEMP array for imaginary component
NR	Index to TEMP array for real component
NUMYRS	Number of wire segments
NX,NY,NZ	Components of patch normal vector
PHI	Spherical angle ϕ in radians
PHIS	Spherical angle ϕ in degrees
PLNWAV	.TRUE. for plane wave excitation .FALSE. for spherical wave excitation
R	$\geq$ 0 - location of spherical wave source < 0 = plane wave source
RF	Distance from source to specular point
RFI	I/RF
RHO	Reflection plane component of RF
RHOSQ	$(RHO)^2$
RI	Distance from source to field point

RINP	In-plane reflection coefficient
ROUT	Out-of-plane reflection coefficient
RS	Location of wave excitation source
RSQ	R^2
SINARG	Imaginary component of $e^{-j\bar{k} \cdot \bar{R}_i}$
SINETA	$(1\text{-COSETA}^2)^{1/2}$
SINP	Sine (ϕ)
SINT	Sine (θ)
T	Logical .TRUE.
T1X,T1Y,T1Z	Internal symbols for SEGTBL parameters
T2X,T2Y,T2Z	Internal symbols for SEGTBL parameters
THETA	θ (radians)
THETS	θ (degrees)
VI	Unused
VMAG	$\lvert \bar{E} + j\varepsilon \overline{EP} \rvert$
VOLTS	Total excitation
VR	Unused
WIRE	Logical .TRUE. if element is a wire
XC	X coordinate of field point
XR	X coordinate of specular point
XS	X coordinate of source point
XW	X component of $\bar{\ell}_i$
YC	Y coordinate of field point
YR	Y coordinate of specular point
YS	Y coordinate of source point

YW	Y component of $\bar{\ell}_i$
ZC	Z coordinate of field point
ZR	Z coordinate of specular point
ZRSQRT	Intermediate value in calculation of RINP and ROUT
ZS	Z coordinate of source point
ZW	Z component of $\bar{\ell}_i$

5. I/O VARIABLES:

A. INPUT

INPUT	LOCATION
DGTORD	/GEODAT/
ECCEN	F.P.
ETA	/AMPZIJ/
ETAP	F.P.
IPERF	/AMPZIJ/
ISGTBL	/SEGMNT/
ISOFF	/ADEBUG/
ISON	/ADEBUG/
KSYMP	/AMPZIJ/
MAXSEG	/SEGMNT/
NAMEXC	F.P.
NDXBLK	/SEGMNT/
NPATCH	/SEGMNT/
NWIRE	/SEGMNT/
PHIS	F.P.
RS	F.P.

SEGTBL	/SEGMNT/
THETS	F.P.
VI	F.P.
VMAG	F.P.
VR	F.P.
WAVNUM	/AMPZIJ/
ZRATI	/AMPZIJ/
B. OUTPUT	LOCATION
TEMP	/TEMP01/
UPDBLK	/SEGMNT/

6. CALLING ROUTINE:

EXCDRV

7. CALLED ROUTINES:

ASSIGN

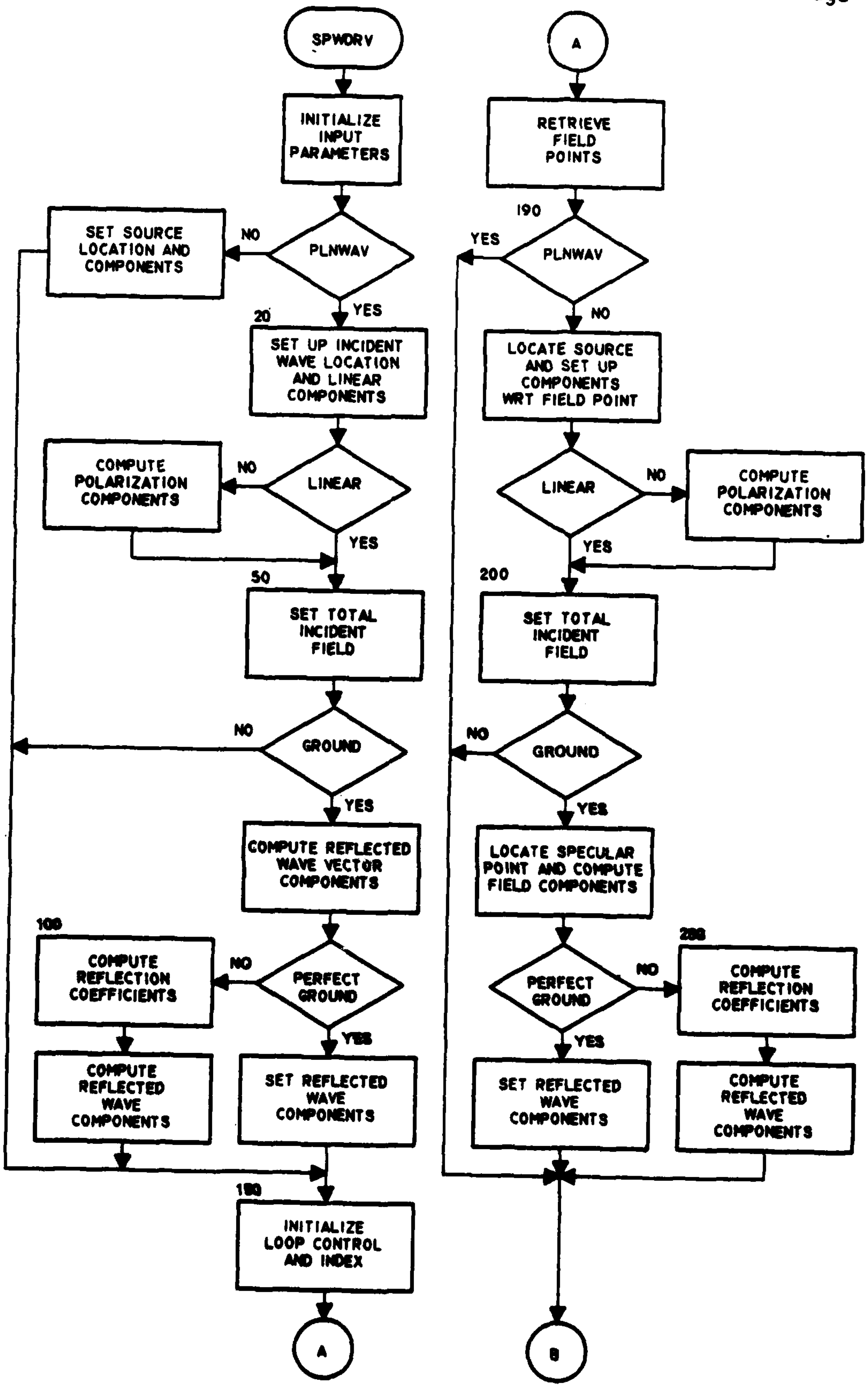
GETSEG

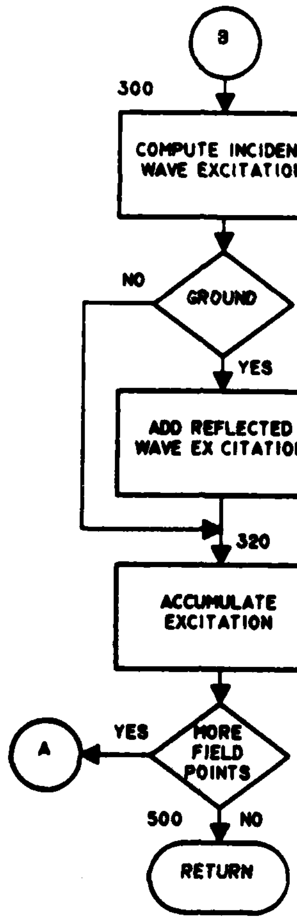
STATIN

STATOT

WLKBCK

SPWDRV (MOM)


SPWDRV
INITIALIZE INPUT PARAMETERS
PLNWAV
NO
SET SOURCE LOCATION AND COMPONENTS
YES
20
SET UP INCIDENT WAVE LOCATION AND LINEAR COMPONENTS
LINEAR
NO
COMPUTE POLARIZATION COMPONENTS
YES
50
SET TOTAL INCIDENT FIELD
GROUND
NO
YES
COMPUTE REFLECTED WAVE VECTOR COMPONENTS
PERFECT GROUND
NO
100
COMPUTE REFLECTION COEFFICIENTS
COMPUTE REFLECTED WAVE COMPONENTS
YES
SET REFLECTED WAVE COMPONENTS
INITIALIZE LOOP CONTROL AND INDEX
A
RETRIEVE FIELD POINTS
190
PLNWAV
YES
NO
LOCATE SOURCE AND SET UP COMPONENTS WRT FIELD POINT
LINEAR
NO
COMPUTE POLARIZATION COMPONENTS
YES
200
SET TOTAL INCIDENT FIELD
GROUND
NO
YES
LOCATE SPECULAR POINT AND COMPUTE FIELD COMPONENTS
PERFECT GROUND
NO
COMPUTE REFLECTION COEFFICIENTS
COMPUTE REFLECTED WAVE COMPONENTS
YES
SET REFLECTED WAVE COMPONENTS
B


B
300
COMPUTE INCIDENT WAVE EXCITATION
GROUND
NO
YES
ADD REFLECTED WAVE EX CITATION
320
ACCUMULATE EXCITATION
MORE FIELD POINTS
YES
A
500
NO
RETURN

1. NAME: STATFN (GTD, INPUT, MOM, OUTPUT)

2. PURPOSE: Subroutine to print the timing statistics compiled during code execution and to write the end-of-module checkpoint.

3. METHOD: The number of times a subroutine is entered, the total time to run the subroutine, and its percentage of the total code execution time are compiled and printed.

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
IMDCHK	Flag indicating that an end-of-module checkpoint is being written
ITEMS	Dummy array used to store the subroutine times for sorting
J	Pointer to the next subroutine statistics to be printed
LOC	An order array used to indicate the sorted subroutine timing statistics
MODCHK	End-of-module checkpoint file logical unit
NITEMS	The number of entries for which there will be timing statistics
PCNT	The percentage of time spent in any one subroutine
RITEMS	Real array equivalenced to ITEMS
TOTAL	Total amount of GEMACS code computer time accounted for in subroutines

5. I/O VARIABLES:

A. INPUT

INPUT	LOCATION
CHKPNT	/SYSFIL/
IERRF	/ADEBUG/
IOCKPT	/SYSFIL/
ISOFF	/ADEBUG/

ISON	/ADEBUG/
LUPRNT	/ADEBUG/
MODCHK	/SYSFIL/
MODNAM	/MODULE/
NRNAMS	/ADEBUG/
NRSUBS	/ADEBUG/
NRTIMS	/ADEBUG/
RSUMS	/ADEBUG/

B. OUTPUT LOCATION

COMPLT	/SYSFIL/
IMDCHK	/ADEBUG/
LSTMOD	/MODULE/
MODLST	/MODULE/
RSTRTA	/SYSFIL/

6. CALLING ROUTINES:

MAIN PROGRAM

ERROR

7. CALLED ROUTINES:

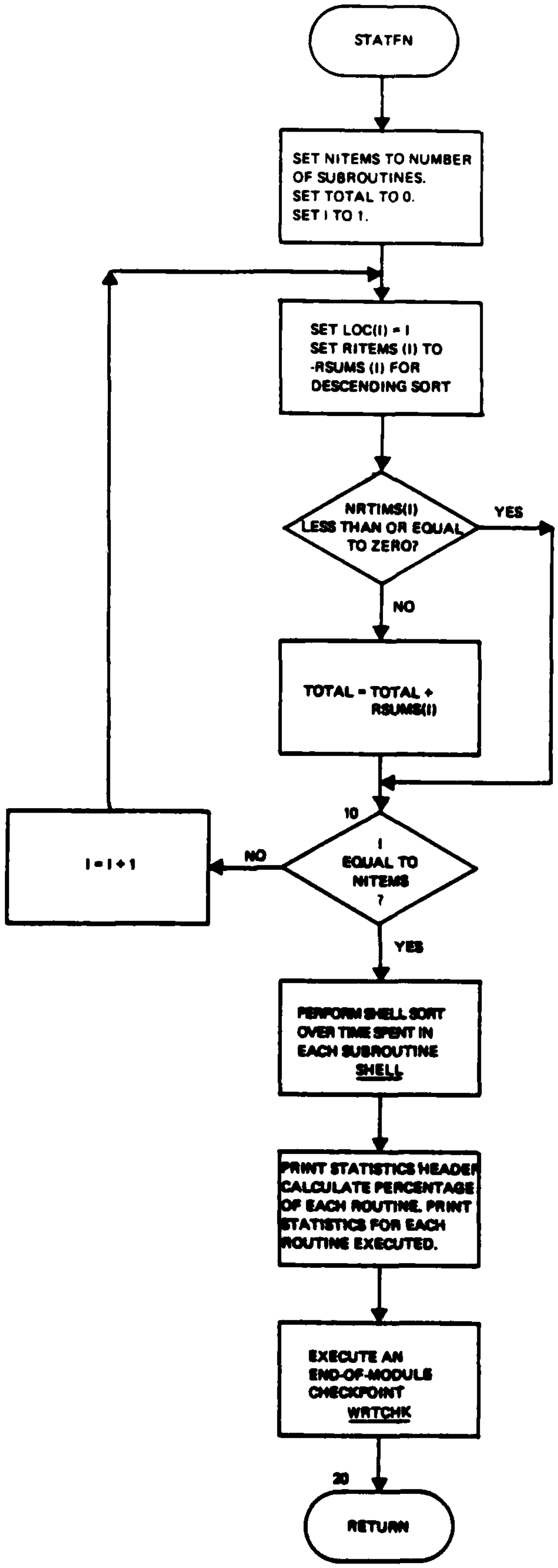
CLSFIL

OPNFIL

SHELL

WRTCHK

STATFN (GTD, INPUT, MOM, OUTPUT)



1. NAME: STATIN (GTD, INPUT, MOM, OUTPUT)

2. PURPOSE: To initialize timing statistics for all subroutines which call it.

3. METHOD: The current wall clock time is entered into the RTINS array. The NRTIMS array is incremented by 1 and the total time in the previous subroutine is loaded in the RSUMS array.

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
MSAVE	Input array containing the statistics for the previous subroutine.
N	Subroutine number of the previous subroutine to call this routine.
NAME	Input argument, current subroutine name.
NRTIMS	Array to accumulate the number of times a given subroutine is entered.
NUMSB	Subroutine number of calling subroutine.
RSUMS	Total time accumulated in the previous subroutine to call this routine.
RTINS	The current clock time for the current subroutine calling this subroutine.
TIMIN	Current clock time.

5. I/O VARIABLES:

A. INPUT

INPUT	LOCATION
ISON	/ADEBUG/
LTRACE	/ADEBUG/
LUPRNT	/ADEBUG/
MSAVE	F.P.
NAME	F.P.
NUMSB	F.P.

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STATIN (GTD, INPUT, MOM, OUTPUT)

B.	OUTPUT	LOCATION
	NRTIMS	/ADEBUG/
	RSUMS	/ADEBUG/
	RTINS	/ADEBUG/

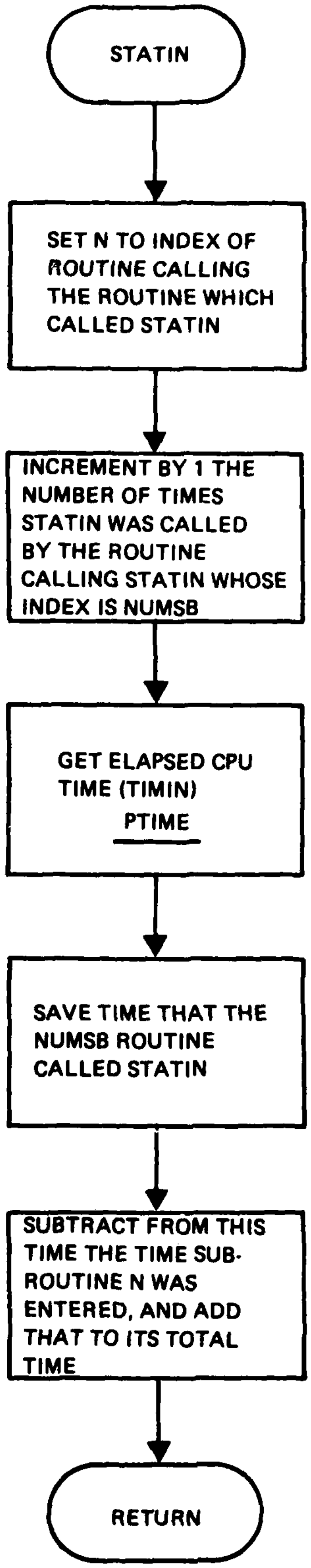
6. CALLING ROUTINES:

All major routines.

7. CALLED ROUTINES:

NONE

STATIN (GTD, INPUT, MOM, OUTPUT)



1. NAME: STATOT (GTD, INPUT, MOM, OUTPUT)

2. PURPOSE: To close the timing statistic upon exit from a subroutine.

3. METHOD: The index of the calling subroutine is retrieved. The wall clock time is then determined, and the accumulated time for the current subroutine is determined. Then the clock is restarted for the subroutine which called the calling subroutine.

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
MSAVE	Input argument array containing the subroutine which called the calling subroutine
N	The subroutine number of the subroutine which called the calling subroutine
NAME	Input argument containing the name of the subroutine for which the statistic is being accumulated
NUMSB	The subroutine number of the subroutine for which the statistic is being accumulated
RSUMS	The accumulated time spent in the subroutine for which the statistic is being accumulated
RTINS	The current time reset for the subroutine which called the calling subroutine
TIMOUT	Current wall clock time

5. I/O VARIABLES:

A. INPUT

INPUT	LOCATION
ISON	/ADEBUG/
LTRACE	/ADEBUG/
LUPRNT	/ADEBUG/
MSAVE	F.P.
NAME	F.P.
NUMSB	F.P.

PREVIOUS PAGE IS BLANK

B. OUTPUT	LOCATION
RSUMS	/ADEBUG/
RTINS	/ADEBUG/

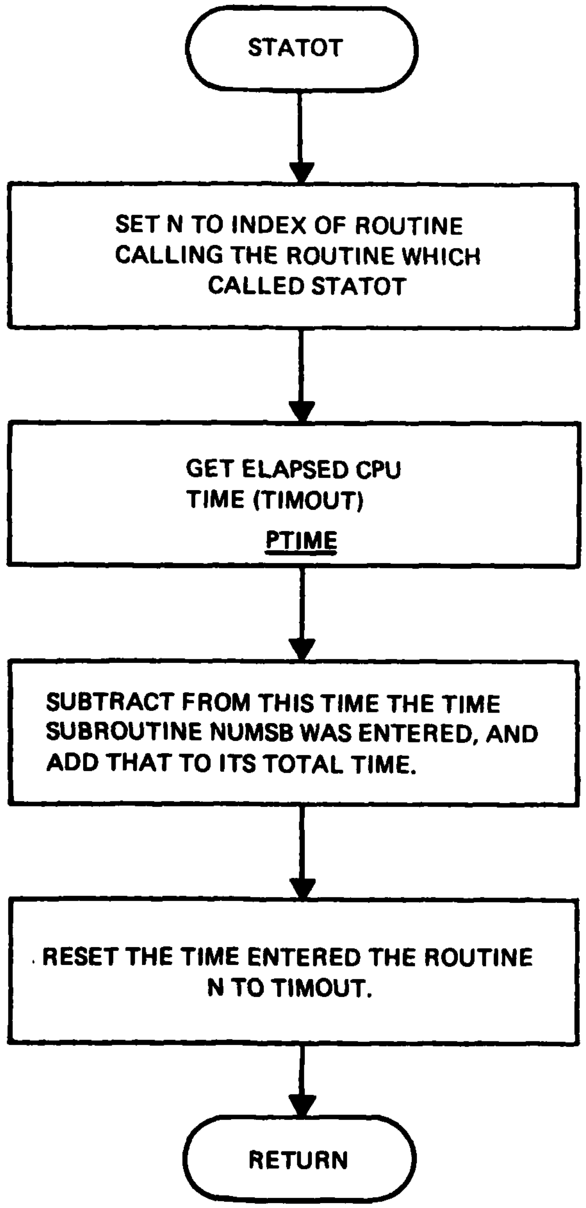
6. CALLING ROUTINES:

All major routines.

7. CALLED ROUTINES:

None.

STATOT (GTD, INPUT, MOM, OUTPUT)



1. NAME: STRTUP (GTD, MOM, OUTPUT)

2. PURPOSE: Initalize commons and reset data files to begin module execution.

3. METHOD: The last checkpoint on module checkpoint file MODCHK is read to initialize commons and read in data files. If the RSTART flag is on, the module name requested in the RESTRT command is compared to the name of this module. If they do not match, execution stops so that this same checkpoint can be used by a subsequent module for restarting. If a match occurs, the routine returns to GEMACS, which invokes TSKXQT to continue execution.

   For standard module start-up (no RSTART flag), the error flag is first checked. If an error occurred in a previous module, execution is terminated with an appropriate warning message. Otherwise, parameters are reset to their default values and data sets rewound to just before the first word of their first editions.

4. INTERNAL VARIABLES:

VARIABLE	DESCRIPTION
I	Loop index pointing to symbol table entry
ICHKPT	Maximum number of checkpoints on tape
ICKLOP	Loop index over number of checkpoints read
IEOF	Flag indicating end-of-file on LUFILE
IOSTOR	Logical unit number of data set
IRSAV	Internal variable to save value of IRSTRT
J	Loop index over module names
KCODE	Array of keyword numbers describing module names
LOCNOW	Present position of data file
LUFILE	Internal variable set to MODCHK
MOD	Array of Hollerith format module names
MODNOW	Internal variable equal to MODNAM
NREAD	Flag set to ISOFF so that commons and files are read from MODCHK

5. I/O VARIABLES:

A. INPUT — LOCATION

INPUT	LOCATION
IERRF	/ADEBUG/
IOFILE	/IOFLES/
IRSTRT	/ADEBUG/
ISOFF	/ADEBUG/
ISON	/ADEBUG/
KOLAST	/PARTAB/
KOLFST	/PARTAB/
KOLLOC	/PARTAB/
LSTMOD	/MODULE/
LSTSYS	/SYSFIL/
LUPRNT	/ADEBUG/
MODCHK	/SYSFIL/
MODLST	/MODULE/
MODNAM	/MODULE/
NDATBL	/PARTAB/
NPDATA	/PARTAB/

B. OUTPUT — LOCATION

OUTPUT	LOCATION
CHKWRT	/SYSFIL/
DBGPRT	/ADEBUG/
FRQMHZ	/AMPZIJ/
IMDCHK	/ADEBUG/
IRSTRT	/ADEBUG/
KJFLD	/INTMAT/

KJGTD	/INTMAT/
KJMOM	/INTMAT/
NDATBL	/PARTAB/
NOSTAT	/ADEBUG/
RSTART	/SYSFIL/

6. CALLING ROUTINE:

   GEMACS

7. CALLED ROUTINES:

   ASSIGN

   GETSYM

   MOVFIL

   PUTSYM

   RDEFIL

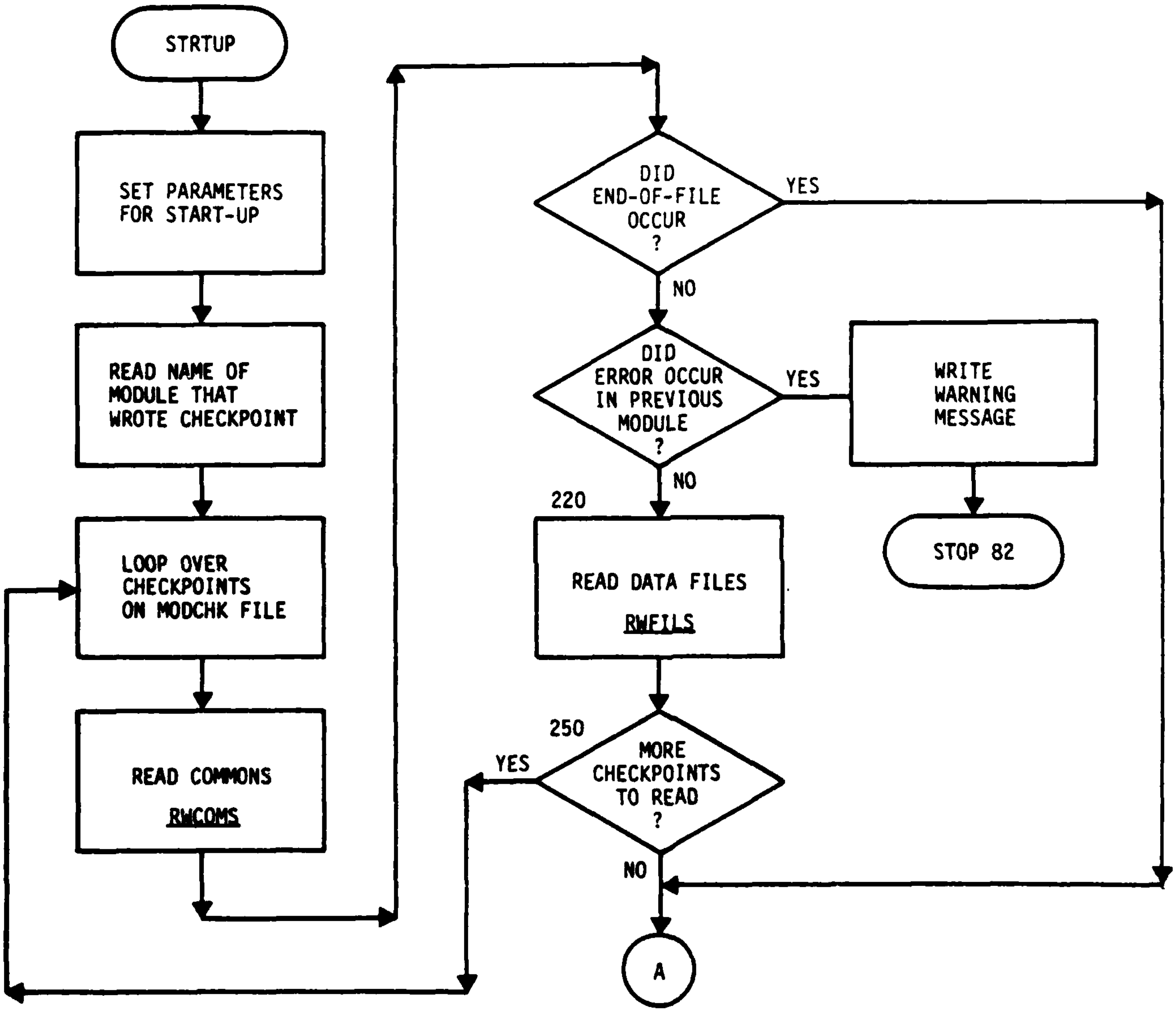
   RWCOMS

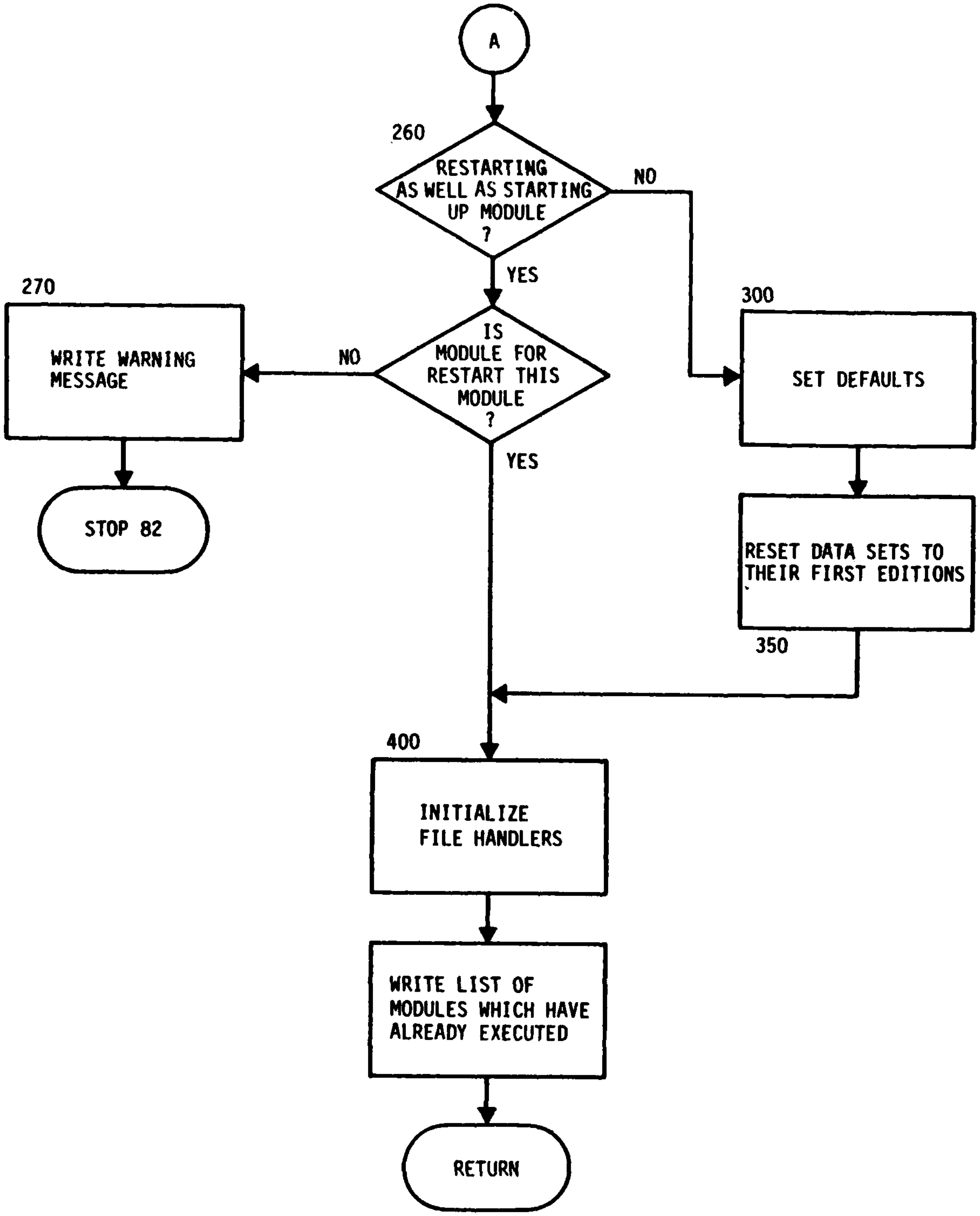
   RWFILS

   STATIN

   STATOT

   WLKBCK


STRTUP
SET PARAMETERS FOR START-UP
READ NAME OF MODULE THAT WROTE CHECKPOINT
LOOP OVER CHECKPOINTS ON MODCHK FILE
READ COMMONS
RWCOMS
DID END-OF-FILE OCCUR ?
YES
NO
DID ERROR OCCUR IN PREVIOUS MODULE ?
YES
WRITE WARNING MESSAGE
STOP 82
NO
220
READ DATA FILES
RWFILS
250
MORE CHECKPOINTS TO READ ?
YES
NO
A


A
260
RESTARTING AS WELL AS STARTING UP MODULE ?
NO
YES
270
WRITE WARNING MESSAGE
NO
IS MODULE FOR RESTART THIS MODULE ?
YES
300
SET DEFAULTS
STOP 82
RESET DATA SETS TO THEIR FIRST EDITIONS
350
400
INITIALIZE FILE HANDLERS
WRITE LIST OF MODULES WHICH HAVE ALREADY EXECUTED
RETURN

1. NAME: SUBPAT (INPUT)

2. PURPOSE: Augments the segment table when a wire-patch connection is found.

3. METHOD: First, the subroutine SUBPAT determines the maximum number of entries and the maximum number of data blocks that will result from all wire-patch connections. Then, the segment table is searched for the first patch that is connected to a wire segment. This patch is divided into four smaller patches of equal area and oriented with respect to the surface vectors $\hat{t}_1$ and $\hat{t}_2$ as shown in figure 1.

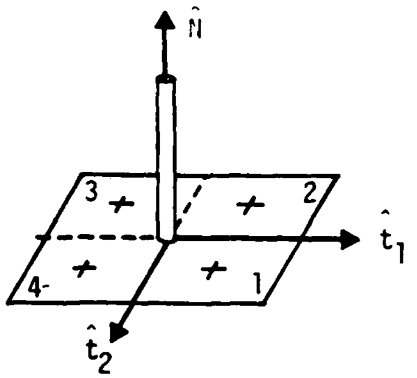


Figure 1. Orientation of Subpatches Connected to a Wire Segment

Also, the unit vector of each of the smaller patches is the same as that of the original patch. The geometry data of the four subpatches are stored in a temporary array along with all succeeding patch data and any patches augmented by a connection to a wire. After all patches have been searched, the data in the temporary array are stored in the segment table starting at the point where the first wire-patch connection was found. Finally, all wire segments are checked for a connection to a patch. If such a connection is found, the connection data are corrected to reflect the new patch number which has resulted from the increase in the number of patches due to a wire-to-patch connection.

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
AREA	Surface area of patch
IBLK	Index for wire segment data blocks

IBLKSV	The index to the data block which locates the first patch connected to a wire segment
ICOL	Number of columns in the connection array
ICOLSV	Saved value of ICOL
ICON	Connection data for wire segment
ICON1	Connection data for end 1 of wire segment
ICON2	Connection data for end 2 of wire segment
ICONT	Flag indicating whether a wire segment connected to patch has been found
IFILE	Logical unit on which symbol is stored
ILIM	The number of segments in requested data block
INBLKS	The data block with the first wire segment-to-patch connection
INPBLK	Index to data block containing the initial patch data
IOFILE	An array containing current position pointer for the search file
IOSCR2	Scratch file for temporary storage of SEGTBL data
IPCN1	Integer identifying which patch is connected to end 1 of wire segment
IPCN2	Integer identifying which patch is connected to end 2 of wire segment
IPLIM	The number of patches in requested data block
IPLOW	The location of first patch in requested data block
IROW	Number of rows in connection data array
ISEGSV	Location within data block of first patch with connection to a wire segment

ITAG	Tag identifier
IWORDS	Equivalenced to WORDS
JBIAS3	Integer to bias connection data to a patch
JMAX	The number of connections in each column of connection array
MAXBLK	Total number of data blocks
MAXSEG	Maximum number of segments per data block
MBLK	The total number of data blocks after accounting for wire segment-to-patch connections
MXBLKW	The total number of data blocks containing wire segments
NCON	An array containing the old and new patch numbers for a wire segment-to-patch connection
NCONT	The number of wire segment-to-patch connections
NDXBLK	Index to current data block
NELMNT	The original number of wires and patches before augmenting for wire segment-to-patch connections
NN	Counter for a new location of patches in SEGTBL
NNCON	Maximum length of array containing old and new patch numbers for wire segment-to-patch connections
NOGOFG	No go flag
NOLD	Original patch number before patches were divided
NPATCH	The total number of patches
NPRSEG	The number of data items for each SEGTBL entry

NUMSEG	The total number of wire segments and patches adjusted for wire-to-patch connections
NUMWP	Number of wire segments and patches in geometry
NWIRE	The total number of wire segments
NXTBLK	Index to the next data block
RH	$\sqrt{(XNPA * XNPA + YNPA * YNPA)}$
SIDE	The x or y dimension for the distance from the center point of the patch to the center point of a subpatch
T1X,T1Y,T1Z	The x,y, and z components of $\hat{t}_1$
T2X,T2Y,T2Z	The x,y, and z components of $\hat{t}_2$
WORDS	Temporary storage array
XNPA,YNPA,ZNPA	X,Y, and Z components of patch normal vector
XPC,YPC,ZPC	X,Y, and Z components of the center point of the patch
XSUBPA	The x coordinate of the subpatch with respect to the patch center (= SIDE)
YSUBPA	The y coordinate of the subpatch with respect to the patch center (= SIDE)

5. I/O VARIABLES:

A. INPUT

INPUT	LOCATION
IOFILE	/IOFLES/
IOSCR2	/SYSFIL/
IP217	/GEODAT/
ISGTBL	/SEGMNT/
ISOFF	/ADEBUG/

SUBPAT - (INPUT)

ISON	/ADEBUG/
JBIAS3	/SEGMNT/
KBREAL	/PARTAB/
KOLCOL	/PARTAB/
KOLLOC	/PARTAB/
KOLNAM	/PARTAB/
LUPRNT	/ADEBUG/
MAXBLK	/SEGMNT/
MAXSEG	/SEGMNT/
NAMSEG	/SEGMNT/
NCONT	F.P.
NDATBL	/PARTAB/
NDXBLK	/SEGMNT/
NOPCOD	/ADEBUG/
NPATCH	/SEGMNT/
NPDATA	/PARTAB/
NPRSEG	/SEGMNT/
NUMGTD	/GTDDAT/
NUMSEG	/SEGMNT/
NWIRE	/SEGMNT/
SEGTBL	/SEGMNT/
ZERO	/ADEBUG/

B. OUTPUT LOCATION

ISGTBL	/SEGMNT/
MAXBLK	/SEGMNT/

SUBPAT (INPUT)

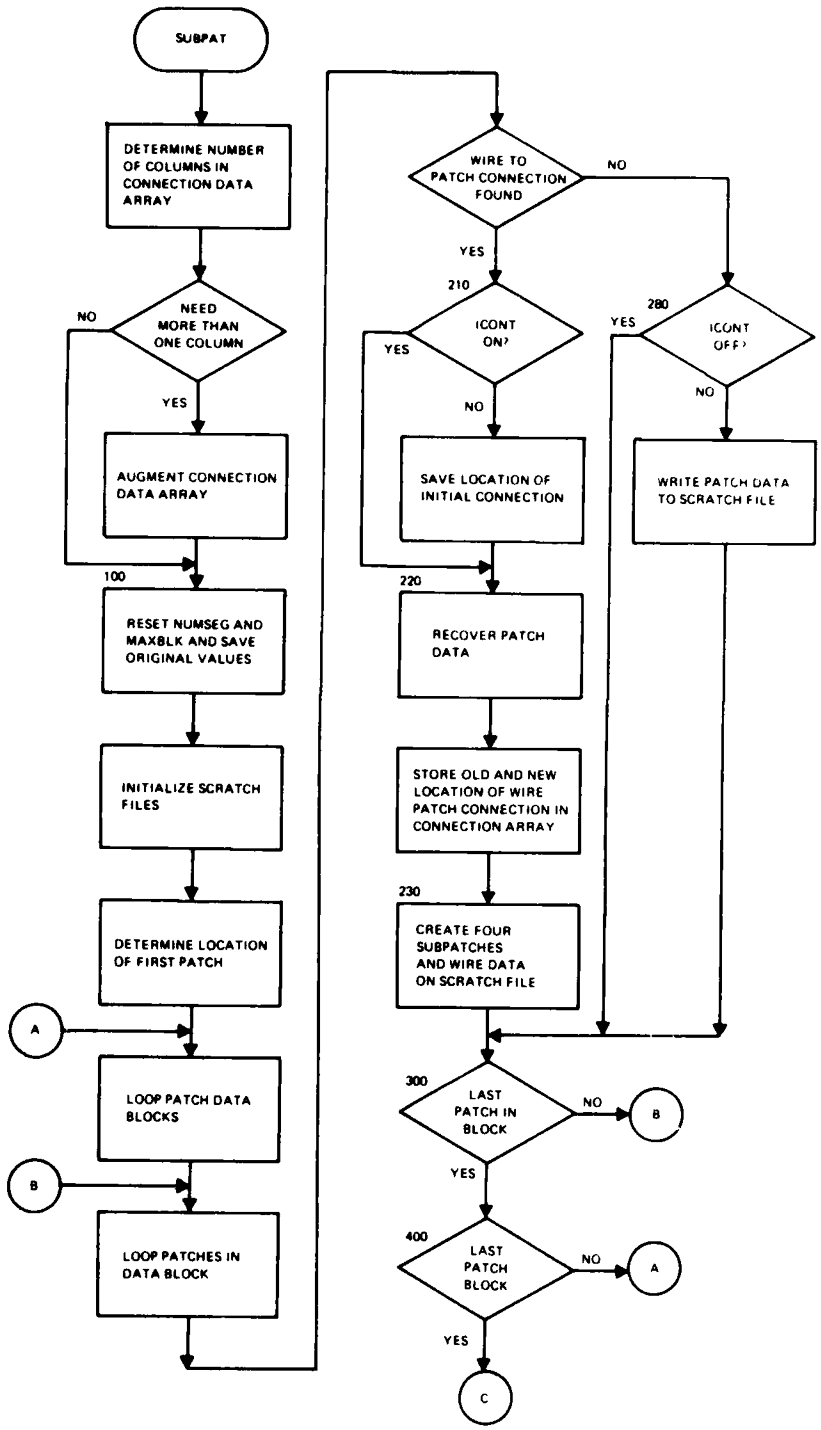
NDATBL	/PARTAB/
NOGOFG	/ADEBUG/
NPATCH	/SEGMNT/
NUMSEG	/SEGMNT/
SEGTBL	/SEGMNT/
UPDBLK	/SEGMNT/

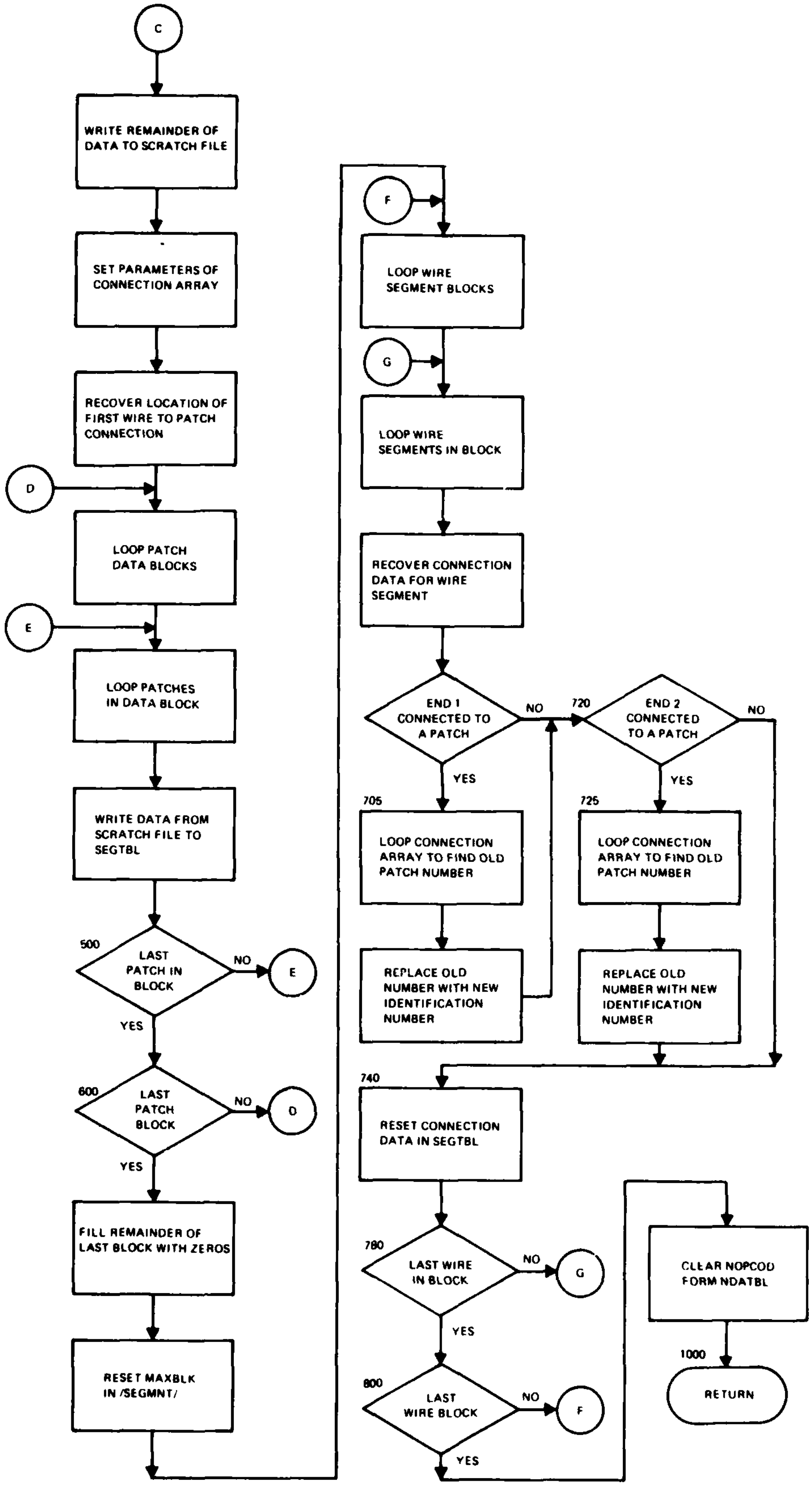
6. CALLING ROUTINE:

   GEODRV

7. CALLED ROUTINES:

ASSIGN	MOVFIL	STATIN	SYMDEF
CLSFIL	OPNFIL	STATOT	WLKBCK
GETSEG	PUTSYM	SYMDEF	WRTFIL
GETSYM	RDEFIL	SYMUPD	


SUBPAT
DETERMINE NUMBER OF COLUMNS IN CONNECTION DATA ARRAY
NEED MORE THAN ONE COLUMN
NO
YES
AUGMENT CONNECTION DATA ARRAY
100
RESET NUMSEG AND MAXBLK AND SAVE ORIGINAL VALUES
INITIALIZE SCRATCH FILES
DETERMINE LOCATION OF FIRST PATCH
A
LOOP PATCH DATA BLOCKS
B
LOOP PATCHES IN DATA BLOCK
WIRE TO PATCH CONNECTION FOUND
NO
YES
210
ICONT ON?
YES
NO
SAVE LOCATION OF INITIAL CONNECTION
220
RECOVER PATCH DATA
STORE OLD AND NEW LOCATION OF WIRE PATCH CONNECTION IN CONNECTION ARRAY
230
CREATE FOUR SUBPATCHES AND WIRE DATA ON SCRATCH FILE
280
ICONT OFF?
YES
NO
WRITE PATCH DATA TO SCRATCH FILE
300
LAST PATCH IN BLOCK
NO
B
YES
400
LAST PATCH BLOCK
NO
A
YES
C


C
WRITE REMAINDER OF DATA TO SCRATCH FILE
SET PARAMETERS OF CONNECTION ARRAY
RECOVER LOCATION OF FIRST WIRE TO PATCH CONNECTION
D
LOOP PATCH DATA BLOCKS
E
LOOP PATCHES IN DATA BLOCK
WRITE DATA FROM SCRATCH FILE TO SEGTBL
500
LAST PATCH IN BLOCK
NO
E
YES
600
LAST PATCH BLOCK
NO
D
YES
FILL REMAINDER OF LAST BLOCK WITH ZEROS
RESET MAXBLK IN /SEGMNT/
F
LOOP WIRE SEGMENT BLOCKS
G
LOOP WIRE SEGMENTS IN BLOCK
RECOVER CONNECTION DATA FOR WIRE SEGMENT
END 1 CONNECTED TO A PATCH
NO
YES
705
LOOP CONNECTION ARRAY TO FIND OLD PATCH NUMBER
REPLACE OLD NUMBER WITH NEW IDENTIFICATION NUMBER
720
END 2 CONNECTED TO A PATCH
NO
YES
725
LOOP CONNECTION ARRAY TO FIND OLD PATCH NUMBER
REPLACE OLD NUMBER WITH NEW IDENTIFICATION NUMBER
740
RESET CONNECTION DATA IN SEGTBL
780
LAST WIRE IN BLOCK
NO
G
YES
800
LAST WIRE BLOCK
NO
F
YES
CLEAR NOPCOD FORM NDATBL
1000
RETURN

1. NAME: SYMDEF (GTD, INPUT, MOM, OUTPUT)

2. PURPOSE: To define or redefine a symbol during program execution.

3. METHOD: The symbol name is searched for in the NDATBL array and if located the warning message is printed out to the user that the symbol is being redefined. If the attributes of the symbol as defined match the attributes in the call to SYMDEF, only a new edition of the symbol is created, not a completely new file. Otherwise, the present symbol is purged from the symbol table, its data file closed, and an entry made in the symbol table with new attributes as specified in the call. Data on the file are lost.

   If not located, the symbol name is added to the end of NDATBL, and the next file available for storage is assigned to the symbol. The file is opened, and the NDATBL pointers are reset. Should there not be a file available, a fatal error is generated. If the addition of this symbol would overflow the NDATBL array, a fatal error is generated.

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
IBIT1	Bit set attributes of present edition of symbol
IBITS	Input attribute containing the bit set attributes of the symbol being defined
INEW	Flag indicating new data set (INEW=1) or new edition of present data set (INEW=0)
IOSTOR	Logical unit designator of file for this symbol
LOCFST	Index to first data entry of this edition of symbol, either core storage or file storage.
LOCLST	Index to last data entry of this edition of symbol, either core storage or file storage.
NAME	User-assigned name of symbol to be defined or redefined

NCOL1	Number of columns defined for present edition of symbol
NCOLS	Number of columns required for symbol being defined or redefined
NEED	Amount of in-core storage required to store data in FLTSYM
NEWSYM	Internal variable for NAME
NPDASV	Saved value of variable NPDATA upon entry to SYMDEF
NROW1	Number of rows defined for present edition of symbol
NROWS	Number of rows required for symbol being defined or redefined
NSYMBL	Number of active entries in the NDATBL array

5. I/O VARIABLES:

A. INPUT

INPUT	LOCATION
DBGPRT	/ADEBUG/
IBITS	F.P.
IOFILE	/IOFLES/
IOSCR1	/SYSFIL/
IOSCR2	/SYSFIL/
IOSYMB	/SYSFIL/
IPASS	/ARGCOM/
ISON	/ADEBUG/
KBCPLX	/PARTAB/
KOLAST	/PARTAB/
KOLBIT	/PARTAB/
KOLCOL	/PARTAB/
KOLFST	/PARTAB/

KOLLOC	/PARTAB/
KOLNAM	/PARTAB/
KOLROW	/PARTAB/
LUPRNT	/ADEBUG/
MAXSTR	/SYMSTR/
NAME	F.P.
NCOLS	F.P.
NDATBL	/PARTAB/
NDATMX	/PARTAB/
NFILES	/IOFLES/
NPDATA	/PARTAB/
NROWS	F.P.
NXTSYM	/SYMSTR/

B. OUTPUT LOCATION

IERRF	/ADEBUG/
NDATBL	/PARTAB/
NPDATA	/PARTAB/
NXTSYM	/SYMSTR/

6. CALLING ROUTINES*:

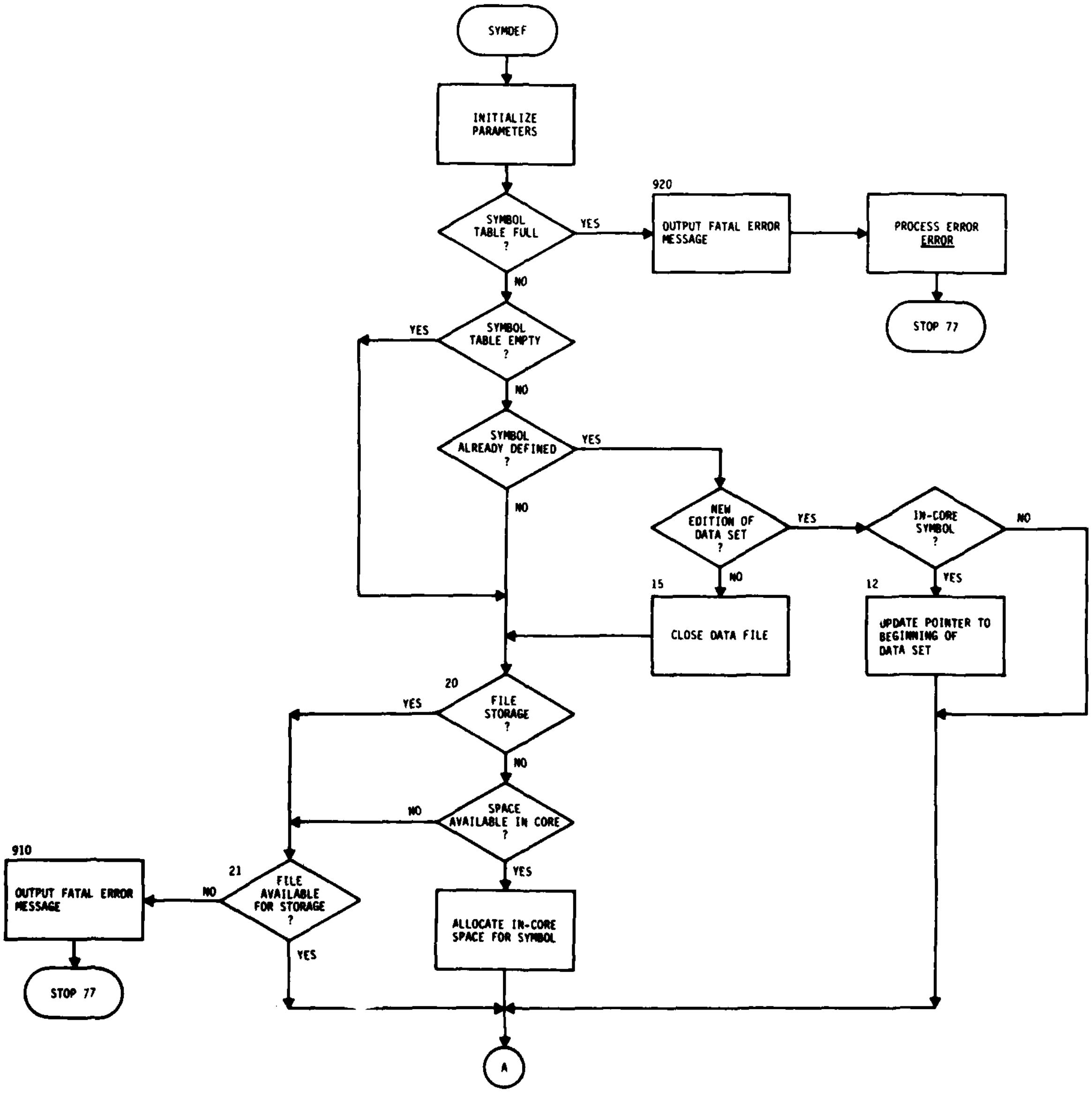
BANDIT (3)	GEODRV (1)	SOLDRV (3)
DMPDRV (1,2,3,4)	LODDRV (3)	SUBPAT (1)
EGFMAT (3)	LUDDRV (3)	TSKXQT (2,3,4)
EXCDRV (2,3)	PUTSYM (1,2,3,4)	ZIJDRV (2,3)
FLDDRV (2,3,4)	SETDRV (3)	

*1-INPUT
2-GTD
3-MOM
4-OUTPUT

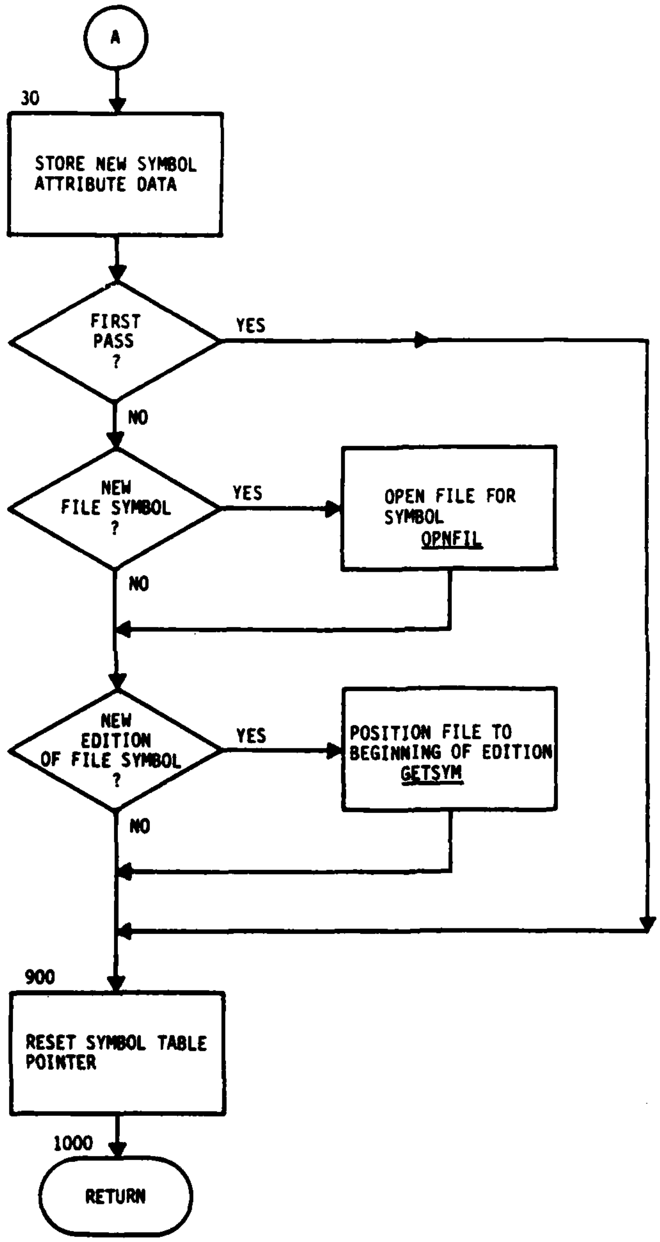
7. CALLED ROUTINES:

ASSIGN	GETSYM	STATOT
CLSFIL	IBITCK	WLKBCK
CONVRT	OPNFIL	
ERROR	STATIN	

SYMDEF (GTD, INPUT, MOM, OUTPUT)



SYMDEF (GTD, INPUT, MOM, OUTPUT)



1. NAME: SYMLIT (INPUT)

2. PURPOSE: Search the symbol and literal tables for the next entry in the scan table and, if found, load the index to the proper table into the next argument list table entry.

3. METHOD: If the next scan table entry is an alpha field, the subroutine SYMSCH is called to find the next scan table entry. If the entry is not found, an error condition is set; if it is found, the index to the symbol table is loaded into the argument list table. If the next scan table entry is not an alpha, subroutine LITSCH is called and the index is returned and loaded into the segment list table.

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
INC	Inline function to position NPARGL
INDEX	Index to symbol table
INDEX1	Index to literal table

5. I/O VARIABLES:

A. INPUT

INPUT	LOCATION
ISOFF	/ADEBUG/
NARGMX	/PARTAB/
NCODE	/SCNPAR/
NPARGL	/PARTAB/
NPEARG	/INPERR/
NPRSER	/SCNPAR/
NTAB	/SCNPAR/
NTALPH	/ADEBUG/
NVAL	/SCNPAR/

B. OUTPUT / LOCATION

OUTPUT	LOCATION
NARGTB	/PARTAB/
NPARGL	/PARTAB/
NPRSER	/SCNPAR/
NUMWRD	/ADEBUG/

6. CALLING ROUTINES:

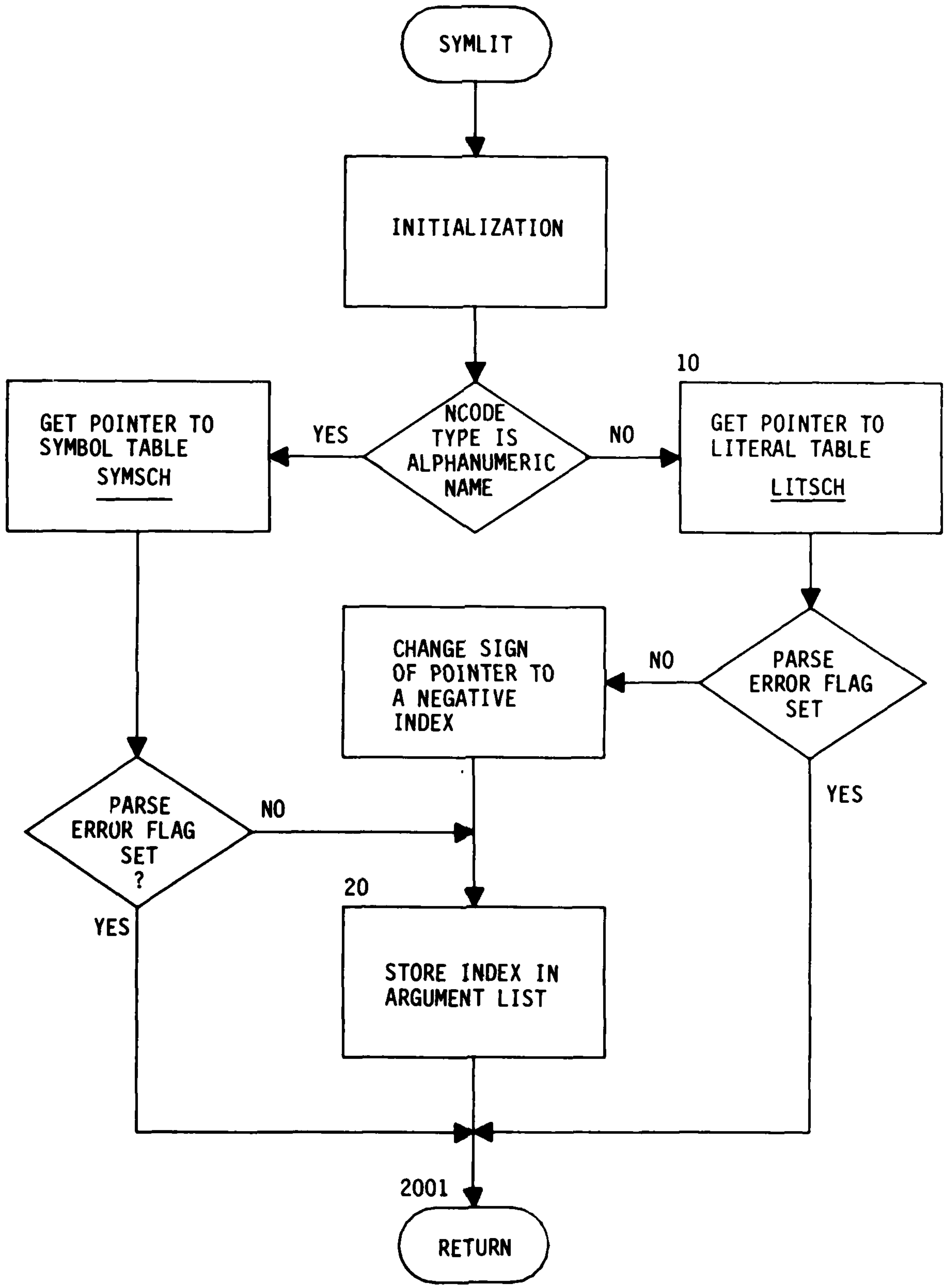
FNDARG

PARSE

7. CALLED ROUTINES

ASSIGN	STATIN	SYMSCH
FABLO2	STATOT	WLKBCK
LITSCH		

SYMLIT (INPUT)



1. NAME: SYMMOD (MOM)

2. PURPOSE: This subroutine forms a symmetrical combination of an input matrix by using an input symmetry operator.

3. METHOD: If Z is a matrix containing N submatrices and S is the matrix representation of the symmetry operator, then the operation

$$[Z] = [S][Z]$$

forms the symmetrical combinations of the submatrices Z.

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
D	Scratch array
DS	Scratch accumulation
IC	Number of columns in the input matrix
IR	Number of rows in the input matrix
IS	Dimension of the symmetry operator
KA	Index pointer
SYMOP	S matrix
Z	Input matrix

5. I/O VARIABLES:

A. INPUT

INPUT	LOCATION
D	F.P.
IC	F.P.
IR	F.P.
IS	F.P.
SYMOP	F.P.
Z	F.P.

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B. OUTPUT — LOCATION

OUTPUT	LOCATION
D	F.P.
Z	F.P.

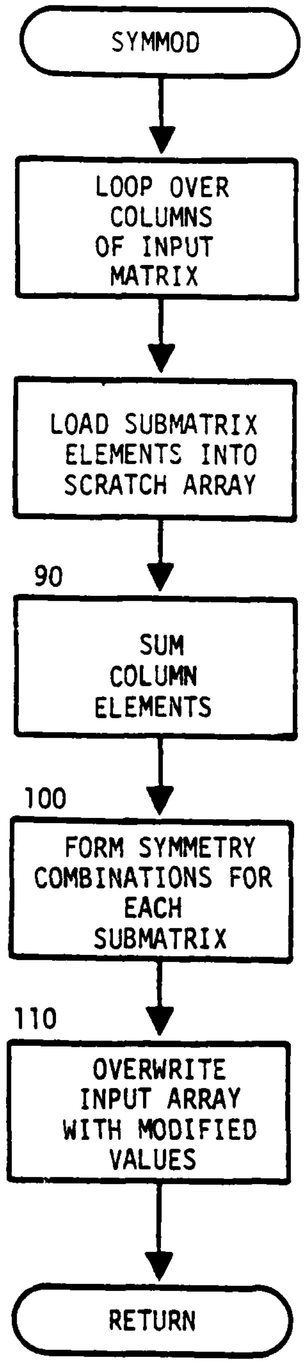
6. CALLING ROUTINES:

SOLDRV

ZIJDRV

7. CALLED ROUTINES:

ASSIGN	STATOT
STATIN	WLKBCK


SYMMOD
LOOP OVER COLUMNS OF INPUT MATRIX
LOAD SUBMATRIX ELEMENTS INTO SCRATCH ARRAY
90
SUM COLUMN ELEMENTS
100
FORM SYMMETRY COMBINATIONS FOR EACH SUBMATRIX
110
OVERWRITE INPUT ARRAY WITH MODIFIED VALUES
RETURN

1. NAME: SYMSCH (INPUT)

2. PURPOSE: Search the NDATBL array for the occurrence of the symbol name specified in the argument list.

3. METHOD: The symbol table is searched for the occurrence of the name specified in the subroutine argument list. If the name is found, and was not supposed to be previously entered, an error flag is set. If the name is not found, and was supposed to be previously entered, an error flag is set. If the name was not found and was not supposed to be previously entered, it is entered into the symbol table and the index is returned through the subroutine argument call.

4. INTERNAL VARIABLES:

VARIABLES	DEFINITION
IEND	Last entry in the symbol table
INDEX	Index to the symbol table
NAME	Symbol name

5. I/O VARIABLES:

A.

INPUT	LOCATION
ISOFF	/ADEBUG/
ISON	/ADEBUG/
KOLNAM	/PARTAB/
MATCH	/SCNPAR/
NAME	F.P.
NDATBL	/PARTAB/
NDATMX	/PARTAB/
NOMTCH	/SCNPAR/
NPDATA	/PARTAB/
NPENOM	/INPERR/
NPESEX	/INPERR/

NPESYM	/INPERR/
NTAB	/SCNPAR/

B. OUTPUT — LOCATION

INDEX	F.P.
NCODE	/SCNPAR/
NDATBL	/PARTAB/
NPDATA	/PARTAB/
NPRSER	/SCNPAR/
NTAB	/SCNPAR/
NUMWRD	/ADEBUG/

6. CALLING ROUTINES:

FNDARG

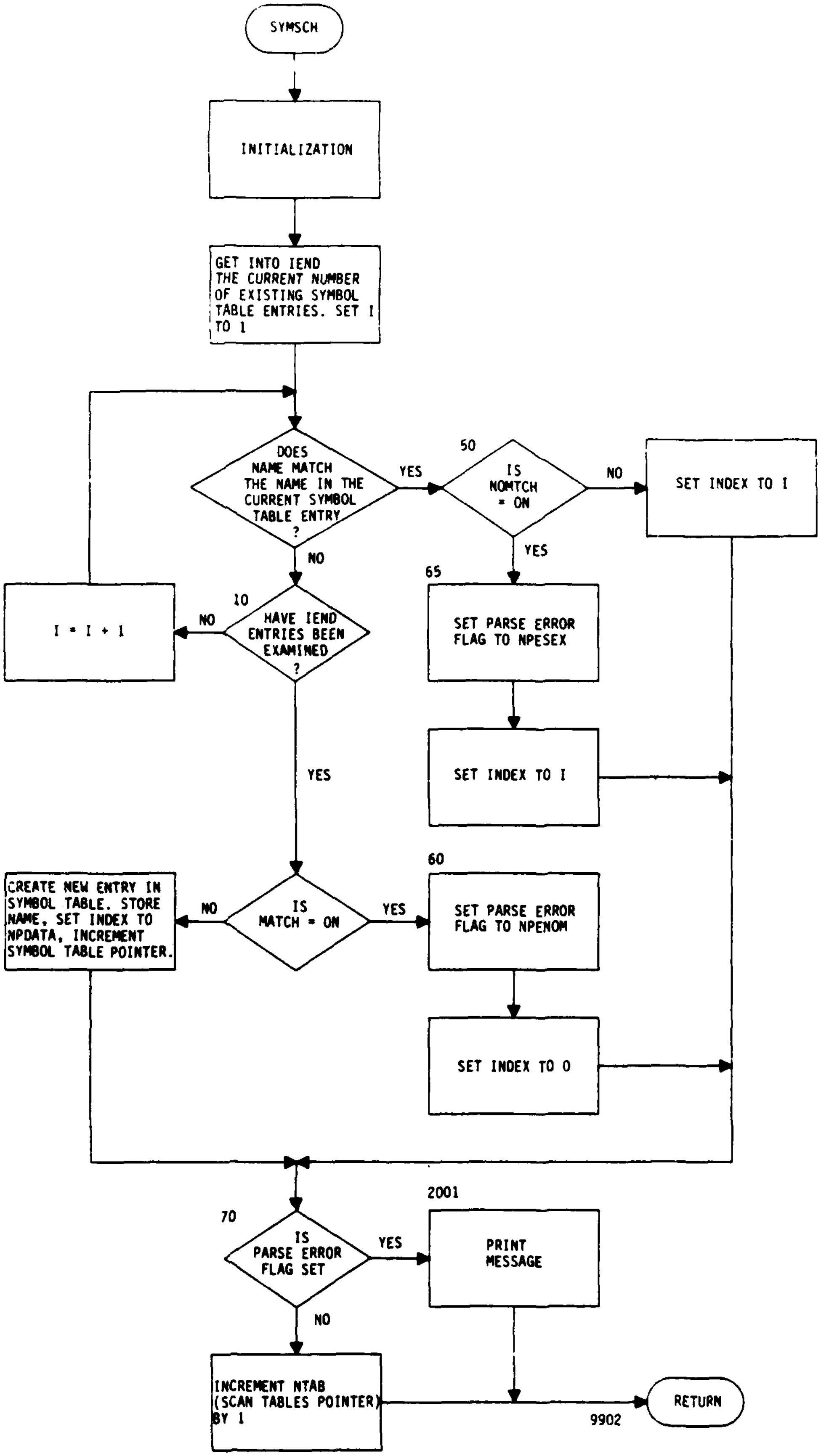
PLIST

SYMLIT

7. CALLED ROUTINES:

ASSIGN	STATOT
FABL02	WLKBCK
STATIN	

SYMSCH (INPUT)



1. NAME: SYMUPD (GTD, INPUT, MOM, OUTPUT)

2. PURPOSE: Update attributes of entries in the NDATBL array.

3. METHOD: The attribute of the symbol to be updated is called through the argument list. The column to be changed in the NDATBL array is checked for validity and, if invalid, a fatal error is generated. If valid, the appropriate column is updated.

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
IFILE	Logical unit on which the symbol is stored
KLM	Input argument designating column of NDATBL array to be changed
KOL	Internal variable for KLM
NAMSYM	Symbolic name for symbol to be updated
NEWDAT	Argument containing new data to be placed in NDATBL array
NEWNAM	Internal representation for argument NAMSYM
NS	Saved value of loop indexed while searching NDATBL array
NSYMBL	Number of entries in the NDATBL array

5. I/O VARIABLES:

A. INPUT

INPUT	LOCATION
DBGPRT	/ADEBUG/
ISON	/ADEBUG/
KLM	F.P.
KOLAST	/PARTAB/
KOLBIT	/PARTAB/
KOLCOL	/PARTAB/
KOLFST	/PARTAB/

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KOLLNK	/PARTAB/
KOLLOC	/PARTAB/
KOLNAM	/PARTAB/
KOLROW	/PARTAB/
LUPRNT	/ADEBUG/
NATSYM	F.P.
NDATBL	/PARTAB/
NDFILE	/IOFLES/
NEWDAT	F.P.
NPDATA	/PARTAB/

B. OUTPUT — LOCATION

IERRF	/ADEBUG/
NDATBL	/PARTAB/

6. CALLING ROUTINES*:

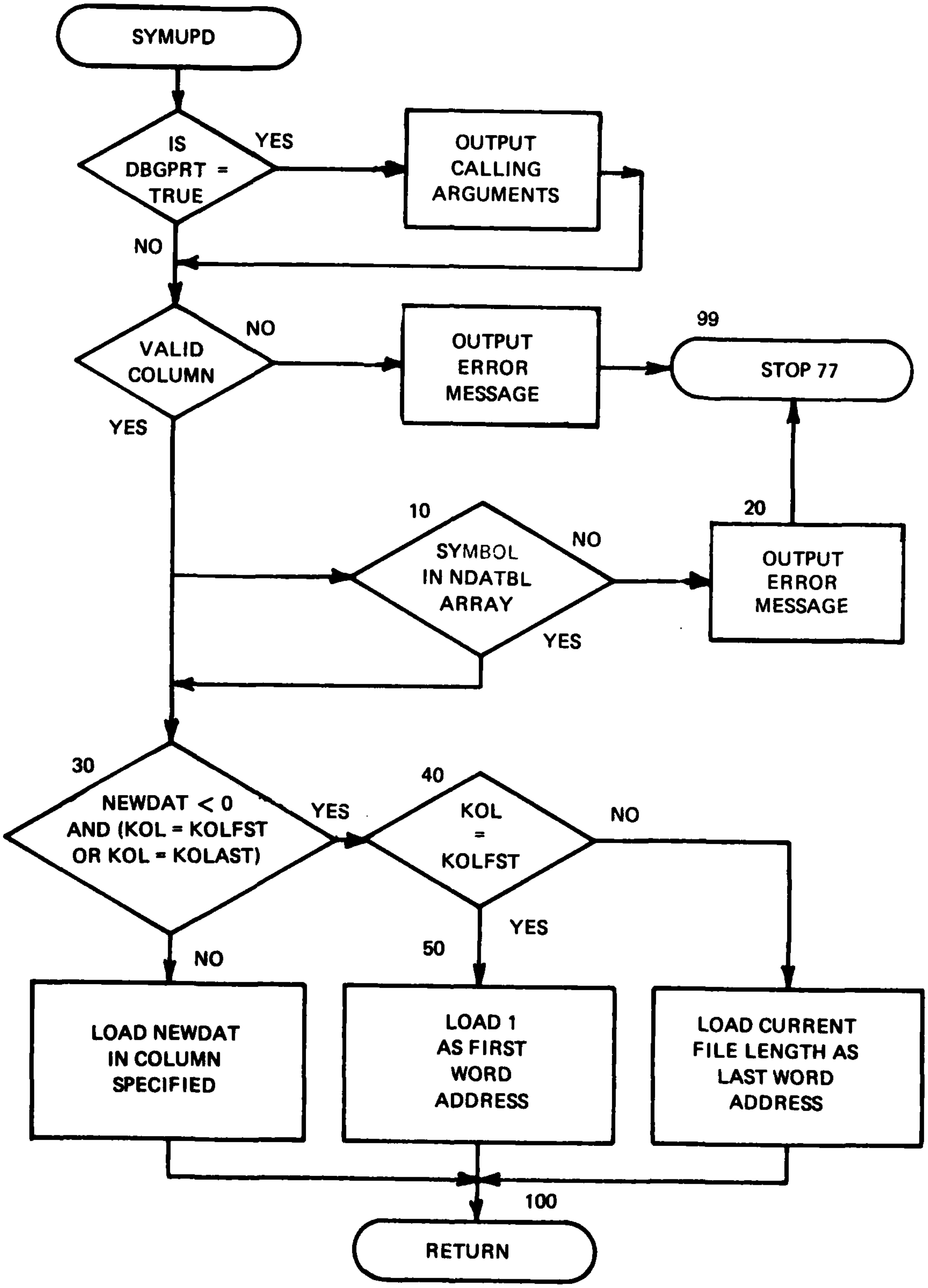
BANDIT (3)	PUTSEG (1,2,3)
EXCDRV (2,3)	SOLDRV (3)
FLDDRV (2,3,4)	SUBPAT (1)
GEODRV (1)	TSKXQT (1,2,3,4)
LODDRV (3)	ZIJDRV (2,3)
LUDDRV (3)	

7. CALLED ROUTINES:

ASSIGN	STATIN
CONVRT	STATOT
ERROR	WLKBCK

*1-INPUT
2-GTD
3-MOM
4-OUTPUT

SYMUPD (GTD, INPUT, MOM, OUTPUT)



1. NAME: SYSCHK (GTD, INPUT, MOM, OUTPUT)

2. PURPOSE: Determine if time for checkpoint has passed.

3. METHOD: The current time is retrieved and if less than the next checkpoint time, control is returned to the calling subroutine. If it is greater than the next checkpoint time, the checkpoint time is incremented and subroutine WRTCHK is called to write a checkpoint.

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
DT	Delta time
ET	Elapsed time from last time check
ETIME	Total elapsed time from beginning of run
FLTINC	Time increment
TIMCHK	Internal variable for checking time elapsed
TLAST	Time of last time checkpoint
TNOW	Current clock time

5. I/O VARIABLES:

A.

INPUT	LOCATION
CHKPNT	/SYSFIL/
COMPLT	/SYSFIL/
INCCHK	/SYSFIL/
ISON	/ADEBUG/
LUPRNT	/ADEBUG/
TIMTGO	/SYSFIL/
ZERO	/ADEBUG/

B.

OUTPUT	LOCATION
COMPLT	/SYSFIL/
IERRF	/ADEBUG/

6. CALLING ROUTINES*:

DECOMP (3)

FLDDRV (2)

TSKXQT (1,2,3,4)

ZIJDRV (2,3)

7. CALLED ROUTINES:

ASSIGN

ERROR

STATIN

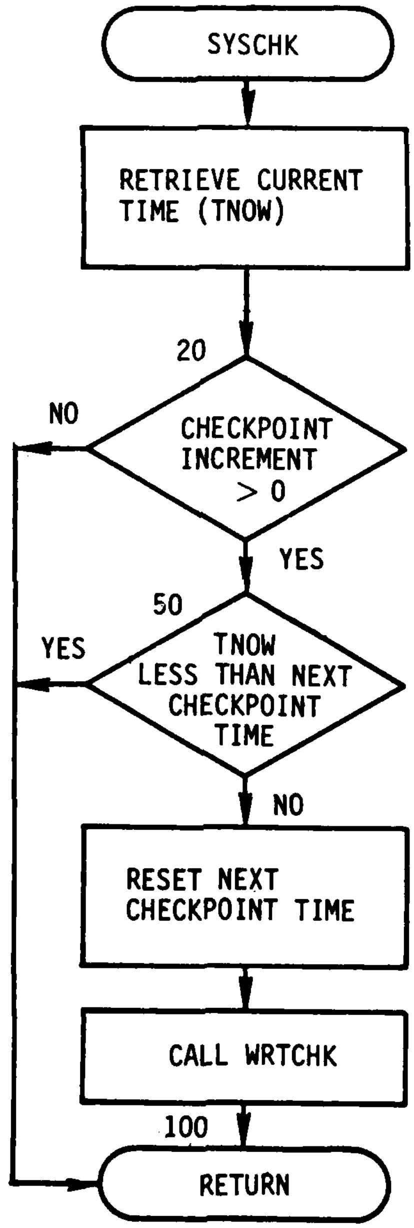
STATOT

TICHEK

WLKBCK

WRTCHK

*1-INPUT
2-GTD
3-MOM
4-OUTPUT


SYSCHK
RETRIEVE CURRENT TIME (TNOW)
20
CHECKPOINT INCREMENT > 0
NO
YES
50
TNOW LESS THAN NEXT CHECKPOINT TIME
YES
NO
RESET NEXT CHECKPOINT TIME
CALL WRTCHK
100
RETURN

1. NAME: SYSRTN (GTD, INPUT, MOM, OUTPUT)

2. PURPOSE: A system-dependent subroutine to return various auxiliary information depending on local subroutine library capability.

3. METHOD: The quantity desired is indicated by the input argument I, and the quantity to be returned is stored in argument variable J.

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
DJ = IJ	Time of day
I	Input argument indicating information desired
IDATE	Date of execution
ITIME	Intermediate value of time of day in minutes
J	Output argument containing information desired.
JHOURS	Intermediate value of time of day (hours)
JMINIT	Intermediate value of time of day (minutes)
TIME	Time of day

NOTE: Explicit form of this subroutine depends on local library subroutines available.

5. I/O VARIABLES:

A. INPUT

INPUT	LOCATION
I	F.P.

B. OUTPUT

OUTPUT	LOCATION
J	F.P.

6. CALLING ROUTINE:

GEMACS

7. CALLED ROUTINES:

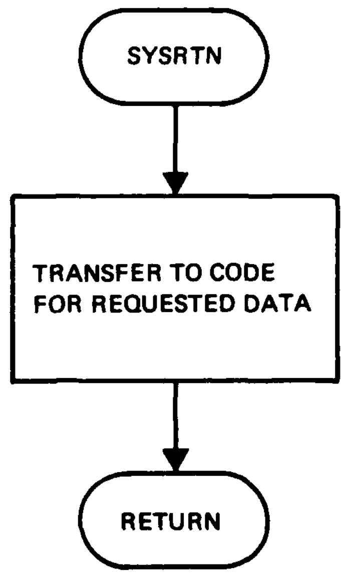
ASSIGN

STATIN

STATOT

WLKBCK

SYSRTN (GTD, INPUT, MOM, OUTPUT)



1. NAME: TANG (GTD)

2. PURPOSE: To compute vectors from a source that are tangent to the cylinder in the x-y plane.

3. METHOD: The unit tangent vectors are determined by solving a set of equations found by setting the incident vector from the source equal to the general unit tangent vector to the elliptic surface. Details are given in pages 90-93 in reference A. General tangents and tangent points are shown in figure 1.

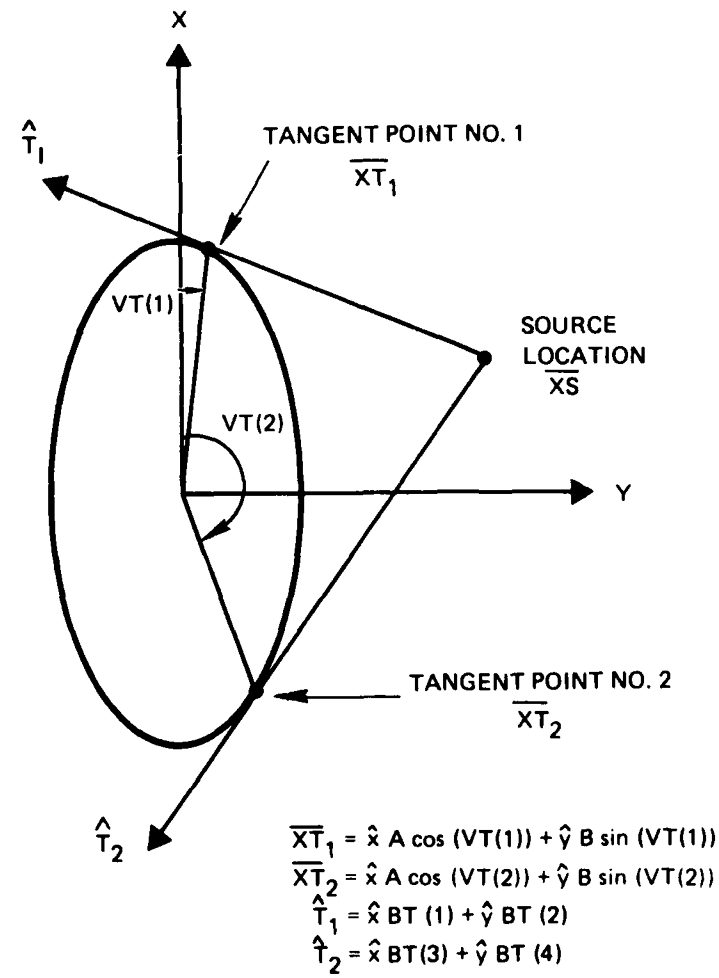


Figure 1. Geometry of Source Vectors Tangent to the Cylinder in the X-Y Plane

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
A	Radius of cylinder along x axis
AA	Distance from source to tangent point
AL	Computational variable
B	Radius of cylinder along y axis
BB	Distance from origin to tangent point
BET	Computational variable
BT	X and Y components of tangent unit vectors in reference coordinate system
CV	Cosine of tangent point elliptical angle
CVE	Cosine of VE
DPR	Degrees per radian (=180./π)
DT	Dot product of unit vectors of the two source rays tangent to the cylinder (2-D)
DV1	Angle V1 in degrees
DV2	Angle V2 in degrees
E1	Error detection variable
E2	Error detection variable
RHOE	Distance from z axis to point where ray from origin to source intersects the cylinder
RHOS	Distance from source to z axis
SV	Sine of tangent point elliptical angle
SVE	Sine of VE
SX	X component of ray from tangent point to source

SY	Y component of ray from tangent point to source
T1X	X component of tangent ray unit vector (tangent point 1)
T1Y	Y component of tangent ray unit vector (tangent point 1)
T2X	X component of tangent ray unit vector (tangent point 2)
T2Y	Y component of tangent ray unit vector (tangent point 2)
V1	Elliptical angle defining tangent point 1
V2	Elliptical angle defining tangent point 2
VE	Elliptical angle of ray from origin to source
VT	Elliptical angle defining tangent point location in RCS x-y plane
XS	Source location
XT	X component of tangent point location
XY	Computational variable
YT	Y component of tangent point location

5. I/O VARIABLES:

A. INPUT

INPUT	LOCATION
A	/GEOMEL/
B	/GEOMEL/
DPR	/PIS/
LUPRNT	/ADEBUG/
XS	F.P.

B. OUTPUT LOCATION

OUTPUT	LOCATION
BT	F.P.
DT	F.P.
VT	F.P.

6. CALLING ROUTINES:

CYLINT

GEOMC

GEOMPC

RPLSCL

SCLRPL

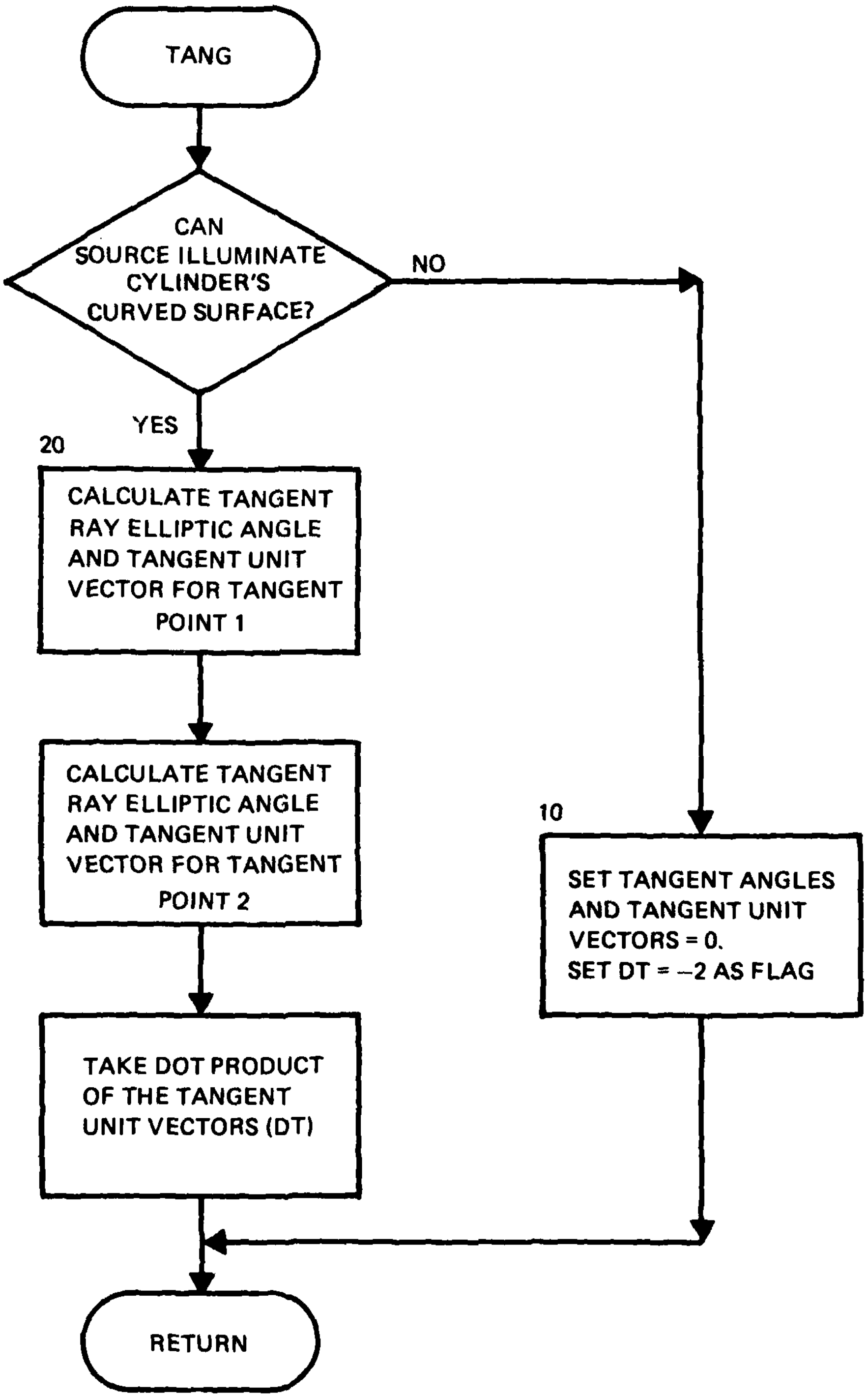
SCTCYL

7. CALLED ROUTINE:

BTAN2

8. REFERENCE:

A. R. J. Marhefka, "Analysis of Aircraft Wing-Mounted Antenna Patterns," Report 2902-25, June 1976, The Ohio State University ElectroScience Laboratory, Department of Electrical Engineering; prepared under Grant No. NGL 36-008-138 for National Aeronautics and Space Administration.


TANG
CAN SOURCE ILLUMINATE CYLINDER'S CURVED SURFACE?
NO
YES
20
CALCULATE TANGENT RAY ELLIPTIC ANGLE AND TANGENT UNIT VECTOR FOR TANGENT POINT 1
CALCULATE TANGENT RAY ELLIPTIC ANGLE AND TANGENT UNIT VECTOR FOR TANGENT POINT 2
TAKE DOT PRODUCT OF THE TANGENT UNIT VECTORS (DT)
10
SET TANGENT ANGLES AND TANGENT UNIT VECTORS = 0.
SET DT = −2 AS FLAG
RETURN

1. NAME: TICHEK (GTD, INPUT, MOM, OUTPUT)

2. PURPOSE: To obtain the current clock time and the time elapsed since the last call to the subroutine.

3. METHOD: The time is initialized to zero and a library subroutine is called to retrieve the current processor time. The elapsed time is computed and the current time is saved for the next call.

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
DT	Output argument for elapsed time since last call
T	Output argument for current processor time
TLAST	Saved value of current processor time to compute DT on next call
TS	Current time in hours

5. I/O VARIABLES:

A. INPUT — LOCATION

None

B. OUTPUT — LOCATION

OUTPUT	LOCATION
DT	F.P.
T	F.P.

6. CALLING ROUTINES:*

DECOMP (3)	WRTCHK (1,2,3,4)
SYSCHK (1,2,3,4)	ZGTDRV (2)
TSKXQT (1,2,3,4)	ZIJSET (3)

7. CALLED ROUTINES:

None.

*1 - INPUT
2 - GTD
3 - MOM
4 - OUTPUT

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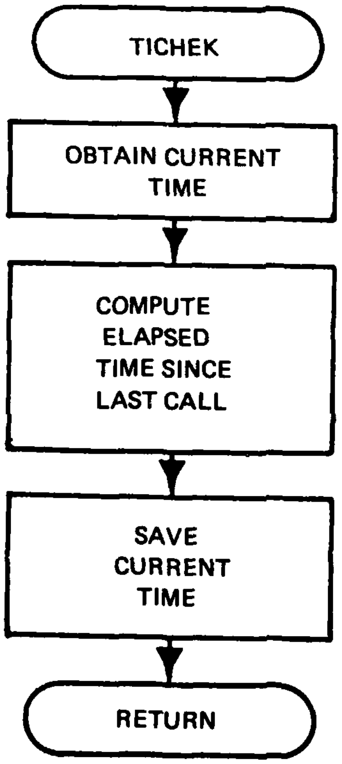
TICHEK (GTD, INPUT, MOM, OUTPUT)



1. NAME: TNEFLD (MOM)

2. PURPOSE: To compute the electric field at a point in space due to the current on a wire segment. The field is computed for three current distributions: sine, cosine, and constant functions of unit amplitude.

3. METHOD: The wire segment is considered to be located at the origin of a local cylindrical coordinate system with the point at which the field is computed being (ρ', ϕ', z'). The geometry for a filament of current of length Δ is shown in figure 1.

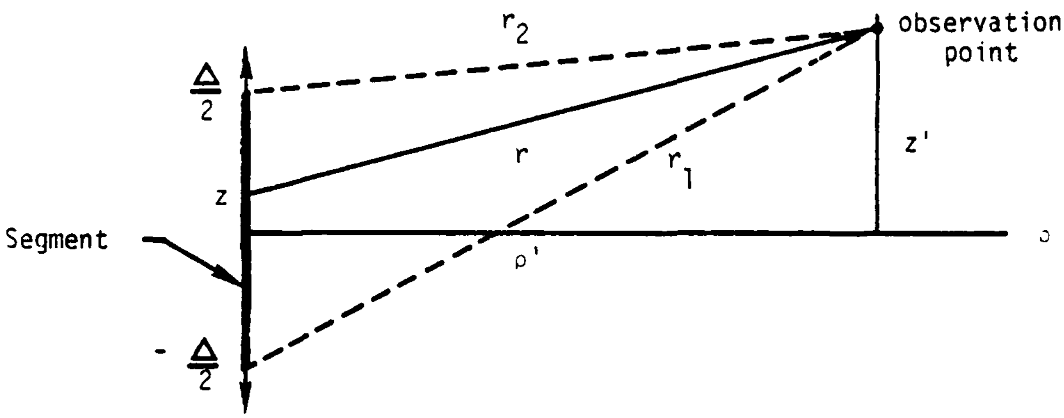


Figure 1. Geometry for Fields Due to a Filament of Current

For a sine or cosine current distribution the field can be written in closed form (see reference A). The ρ and z field components for a current

$$I_o \begin{Bmatrix} \sin kz \\ \cos kz \end{Bmatrix} \text{ are:}$$

$$E_z\ (\rho', z') = I_o\ j\ \frac{\eta}{2} \left[\frac{e^{-jkr_2}}{kr_2} \begin{Bmatrix} \cos k\Delta/2 \\ -\sin k\Delta/2 \end{Bmatrix} - \frac{e^{-jkr_1}}{kr_1} \begin{Bmatrix} \cos k\Delta/2 \\ \sin k\Delta/2 \end{Bmatrix} \right.$$

$$- \left(j + \frac{1}{kr_2}\right) \frac{e^{-jkr_2}}{(kr_2)^2} (kz' - k\Delta/2) \begin{Bmatrix} \sin k\Delta/2 \\ \cos k\Delta/2 \end{Bmatrix}$$

$$+ \left(j + \frac{1}{kr_1}\right) \frac{e^{-jkr_1}}{(kr_1)^2} (kz' + k\Delta/2) \begin{Bmatrix} -\sin k\Delta/2 \\ \cos k\Delta/2 \end{Bmatrix} \Bigg]$$

$$E_\rho (\rho' z') = I_o \left(-j \frac{\eta}{2}\right) \frac{1}{k\rho'} \Bigg[(kz' - k\Delta/2) \frac{e^{-jkr_2}}{kr_2} \begin{Bmatrix} \cos k\Delta/2 \\ -\sin k\Delta/2 \end{Bmatrix}$$

$$- (kz' + k\Delta/2) \frac{e^{-jkr_1}}{kr_1} \begin{Bmatrix} \cos k\Delta/2 \\ \sin k\Delta/2 \end{Bmatrix} + \frac{e^{-jkr_2}}{kr_2} \begin{Bmatrix} \sin k\Delta/2 \\ \cos k\Delta/2 \end{Bmatrix}$$

$$- (kz' - k\Delta/2)^2 \left(j + \frac{1}{kr_2}\right) \frac{e^{-jkr_2}}{(kr_2)^2} \begin{Bmatrix} \sin k\Delta/2 \\ \cos k\Delta/2 \end{Bmatrix}$$

$$- \frac{e^{-jkr_1}}{kr_1} \begin{Bmatrix} -\sin k\Delta/2 \\ \cos k\Delta/2 \end{Bmatrix} + (kz' + k\Delta/2)^2 \left(j + \frac{1}{kr_1}\right)$$

$$\frac{e^{-jkr_1}}{(kr_1)^2} \cdot \begin{Bmatrix} -\sin k\Delta/2 \\ \cos k\Delta/2 \end{Bmatrix} \Bigg]$$

The expression for the field of a constant current distribution involves an integral of exp (-jkr)/r which must be evaluated numerically. The field components for a current I_o are:

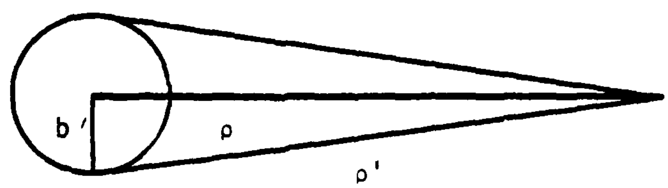
$$E_\rho (\rho', z') = I_o \left(-j \frac{\eta}{2}\right) (k\rho') \left[\left(j + \frac{1}{kr_2}\right) \frac{e^{-jkr_2}}{(kr_2)^2} \right.$$

$$- \left(j + \frac{1}{kr_1} \right) \frac{e^{-jkr_1}}{(kr_1)^2} \Bigg]$$

$$E_z\ (\rho', z') = I_o \left(-j\ \frac{\eta}{2} \right) \Bigg[\int_{-\Delta/2}^{\Delta/2} \frac{e^{-jkr}}{r}\, dz + \left(j + \frac{1}{kr_2} \right)$$

$$(kz' - k\Delta/2) \cdot \frac{e^{-jkr_2}}{(kr_2)^2} - \left(j + \frac{1}{kr_1} \right) (kz' + k\Delta/2)\ \frac{e^{-jkr_1}}{(kr_1)^2} \Bigg]$$

These expressions are separated into real and imaginary parts for evaluation in the program. The coordinate ρ' for a wire segment is taken as the distance from the observation point to a point on the side of the segment as shown in figure 2.



$$\rho' = \left[\rho^2 + b^2 \right]^{1/2}$$

Figure 2. Geometry for the Determination of ρ'

Also, the component E_ρ is multiplied by ρ/ρ' to account for the change in vector direction. The current, I_o, is set to one for evaluation in TNEFLD.

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
B	Radius of wire segment
BK	kb
CINT	$\int_{-\Delta/2}^{\Delta/2} \cos(kr)/r\, dz$
COINC	ρ/ρ'
CR1	$(\eta/2)\cos(kr_1)/(kr_1)$, $(\eta = \sqrt{\mu_o/\varepsilon_o})$
CR1R	$CR1/(kr_1)$
CR1RR	$CR1/(kr_1)^2$
CR2	$(\eta/2)\cos(kr_2)/(kr_2)$
CR2R	$CR2/(kr_2)$
CR2RR	$CR2/(kr_2)^2$
CST	$\cos(k\Delta/2)$
ERIC	Imaginary part of E_ρ for cosine current
ERIK	Imaginary part of E_ρ for constant current
ERIS	Imaginary part of E_ρ for sine current
ERRC	Real part of E_ρ for cosine current
ERRK	Real part of E_ρ for constant current
ERRS	Real part of E_ρ for sine current
ETA	$\eta = \sqrt{\mu_o/\varepsilon_o}$
EZIC	Imaginary part of E_z for cosine current
EZIK	Imaginary part of E_z for constant current
EZIS	Imaginary part of E_z for sine current
EZRC	Real part of E_z for cosine current

EZRK	Real part of E_z for constant current
EZRS	Real part of E_z for sine current
IJX	Flag for numerical integration
IPATCH	A flag indicating a patch observation point
RH	ρ
RHK	$k\rho$
RKB	$k\rho'$
RKB2	$(k\rho')^2$
R1K	kr_1
R1KS	$(kr_1)^2$
R2K	kr_2
R2KS	$(kr_2)^2$
S	Length of segment
SINT	$\int_{-\Delta/2}^{\Delta/2} \sin (kr)/r \, dz$
SKT	$k\Delta/2$
SR1	$(\eta/2) \sin (kr_1)/(kr_1)$
SR1R	$SR1/(kr_1)$
SR1RR	$SR1/(kr_1)^2$
SR2	$(\eta/2) \sin (kr_2)/(kr_2)$
SR2R	$SR2/(kr_2)$
SR2RR	$SR2/(kr_2)^2$
SST	$\sin (k\Delta/2)$

T1, T1S, T2, T2S, T3, T3S, T4, T4S	Temporary storage of terms in electric field expressions
WAVLGH	λ
WAVNUM	$k = 2\pi/\lambda$
ZD1	$kz' + k\Delta/2$
ZD2	$kz' - k\Delta/2$
ZP	z'
ZPK	kz'
ZZ	$\eta/2$, $(\eta = \sqrt{\mu_0/\varepsilon_0})$

5. I/O VARIABLES:

A. INPUT

INPUT	LOCATION
B	/AMPZIJ/
ETA	/AMPZIJ/
IJX	F.P.
ISOFF	/ADEBUG/
RH	F.P.
S	/AMPZIJ/
WAVLGH	/AMPZIJ/
WAVNUM	/AMPZIJ/
ZP	F.P.

B. OUTPUT LOCATION

ERIC,EZIC	F.P.
ERIK,EZIK	F.P.
ERIS,EZIS	F.P.
ERRC,EZRC	F.P.
ERRK,EZRK	F.P.
ERRS,EZRS	F.P.
IJ	/TMI/
IPATCH	/TMI/
RHK	/TMI/
RKB2	/TMI/
ZPK	/TMI/

6. CALLING ROUTINES:

NERFLD

NTRPLT

7. CALLED ROUTINES:

ASSIGN

ROMBNT

STATIN

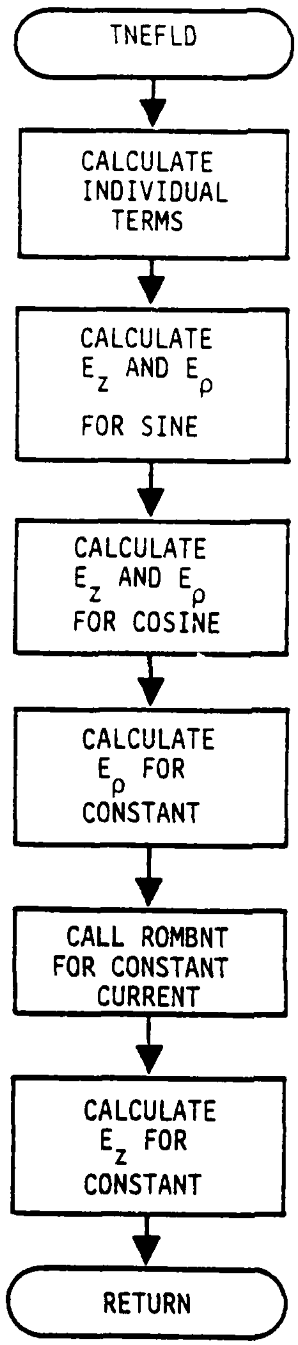
STATOT

WLKBCK

8. REFERENCE:

A. Stratton, J. A. Electromagnetic Theory, McGraw Hill Book Co., New York, 1941, p. 454.

TNEFLD (MOM)


TNEFLD
CALCULATE INDIVIDUAL TERMS
CALCULATE E_z AND E_ρ FOR SINE
CALCULATE E_z AND E_ρ FOR COSINE
CALCULATE E_ρ FOR CONSTANT
CALL ROMBNT FOR CONSTANT CURRENT
CALCULATE E_z FOR CONSTANT
RETURN

1. NAME: TNHFLD (MOM)

2. PURPOSE: To compute the near magnetic field at a point in space due to the current on a wire segment. The field is computed for three current distributions: sine, cosine, and constant functions, each of unit amplitude.

3. METHOD: The wire segment is considered to be located at the origin of a local cylindrical coordinate system with the point at which the field is computed being (ρ', ϕ', z'). The geometry for a filament of current of length Δ is shown in figure 1.

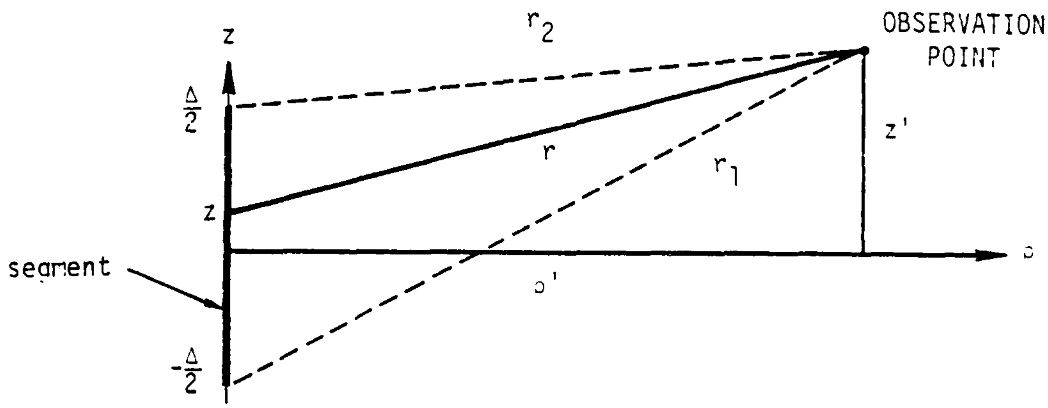


Figure 1. Geometry for Fields Due to a Filament of Current

For a sine or cosine current distribution the field can be written in closed form. The ρ field component for a current

$$I_o \begin{Bmatrix} \sin kz \\ \cos kz \end{Bmatrix} \text{ is:}$$

$$H_\phi(\rho', z') = \frac{-jI_o}{4\pi\rho'}\left\{\exp(-jkr_2)\begin{bmatrix}\cos(k\Delta/2)\\ -\sin(k\Delta/2)\end{bmatrix} - \exp(-jkr_1)\begin{bmatrix}\cos(k\Delta/2)\\ \sin(k\Delta/2)\end{bmatrix}\right.$$

$$- j(z' - \Delta/2)\frac{\exp(-jkr_2)}{r_2}\begin{bmatrix}\sin(k\Delta/2)\\ \cos(k\Delta/2)\end{bmatrix}$$

$$\left. + j(z' + \Delta/2)\frac{\exp(-jkr_1)}{r_1}\begin{bmatrix}-\sin(k\Delta/2)\\ \cos(k\Delta/2)\end{bmatrix}\right\}$$

where $I_o = 1$ is assumed in this routine.

For small values of ρ with $|z'| > \Delta/2$, this equation may produce large numerical errors due to cancellation of large terms. Hence, for $z' > 0$ and $\rho'/(z' \pm \Delta/2) < 10^{-3}$, a more stable approximation for small $\rho'/(z' \pm \Delta/2)$ is used:

$$H_\phi(\rho', z') = \frac{I_o\rho'}{8\pi}\exp(-jkz')\left\{\left[\frac{k}{(z'+\Delta/2)} - \frac{k}{(z'-\Delta/2)}\right]\begin{bmatrix}1\\ -j\end{bmatrix}\right.$$

$$\left. + \left[\frac{\exp(jk\Delta/2)}{(z'-\Delta/2)^2}\begin{pmatrix}\sin(k\Delta/2)\\ \cos(k\Delta/2)\end{pmatrix} - \frac{\exp(-jk\Delta/2)}{(z'+\Delta/2)^2}\begin{pmatrix}-\sin(k\Delta/2)\\ \cos(k\Delta/2)\end{pmatrix}\right]\right\}$$

For $z' < 0$, the above equation is evaluated for $H_\phi(\rho', -z')$. The field of a sin kz current is multiplied by -1 in this case, since it is an odd function of z.

The field due to a constant current is obtained by numerical integration, which is performed by subroutine ROMBNT. If ρ' is zero, all field quantities are set to zero, since H_ϕ is undefined.

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
CDHK	$\cos(k\Delta/2)$
CONST	$1/(4\pi\rho')$
CONST1	$\rho'/8\pi$
CONST2	$\rho' k^2/4\pi$

CR1K	$\cos(kr_1)$
CR2K	$\cos(kr_2)$
CZPK	$\cos(kz')$
DH	$\Delta/2$
DHK	$k\Delta/2$
HPIC,HPRC	The imaginary and real parts of the ϕ component of the magnetic field due to a cosine current
HPIK,HPRK	The imaginary and real parts of the ϕ component of the magnetic field due to a constant current
HPIS,HPRS	The imaginary and real parts of the ϕ component of the magnetic field due to a sine current
HSS	The sign of z
IPATCH	A flag indicating that the magnetic field at a patch is to be computed
RH	ρ'
RHK	$\rho' k$
RHZ	$\rho'/(z' - \Delta/2)$
R1	r_1
R1K	kr_1
R2	r_2
R2K	kr_2
S	Δ, the segment length
SDHK	$\sin(k\Delta/2)$
SR1K	$\sin(kr_1)$
SR2K	$\sin(kr_2)$

SZPK	sin (kz')
T1 T1K T2 T2 T2S T3C T3S	Temporary storage variables used in Ccomputing the magnetic field
WAVNUM	$2\pi/\lambda$
ZD1	$z' + \Delta/2$
ZD2	$z' - \Delta/2$
ZP	z'
ZPK	kz'
ZPSV	Save value of z'

5. I/O VARIABLES

A. INPUT

INPUT	LOCATION
ISON	/ADEBUG/
RH	F.P.
S	/AMPZIJ/
TWOPI	/AMPZIJ/
WAVNUM	/AMPZIJ/
ZP	F.P.

B. OUTPUT

OUTPUT	LOCATION
HPIC,HPRC	F.P.
HPIK,HPRK	F.P.

TNHFLD (MOM)

HPIS,HPRS	F.P.
IPATCH	/TMI/
RHK	/TMI/
ZPK	/TMI/

CALLING ROUTINE:

NTRPLT

CALLED ROUTINES:

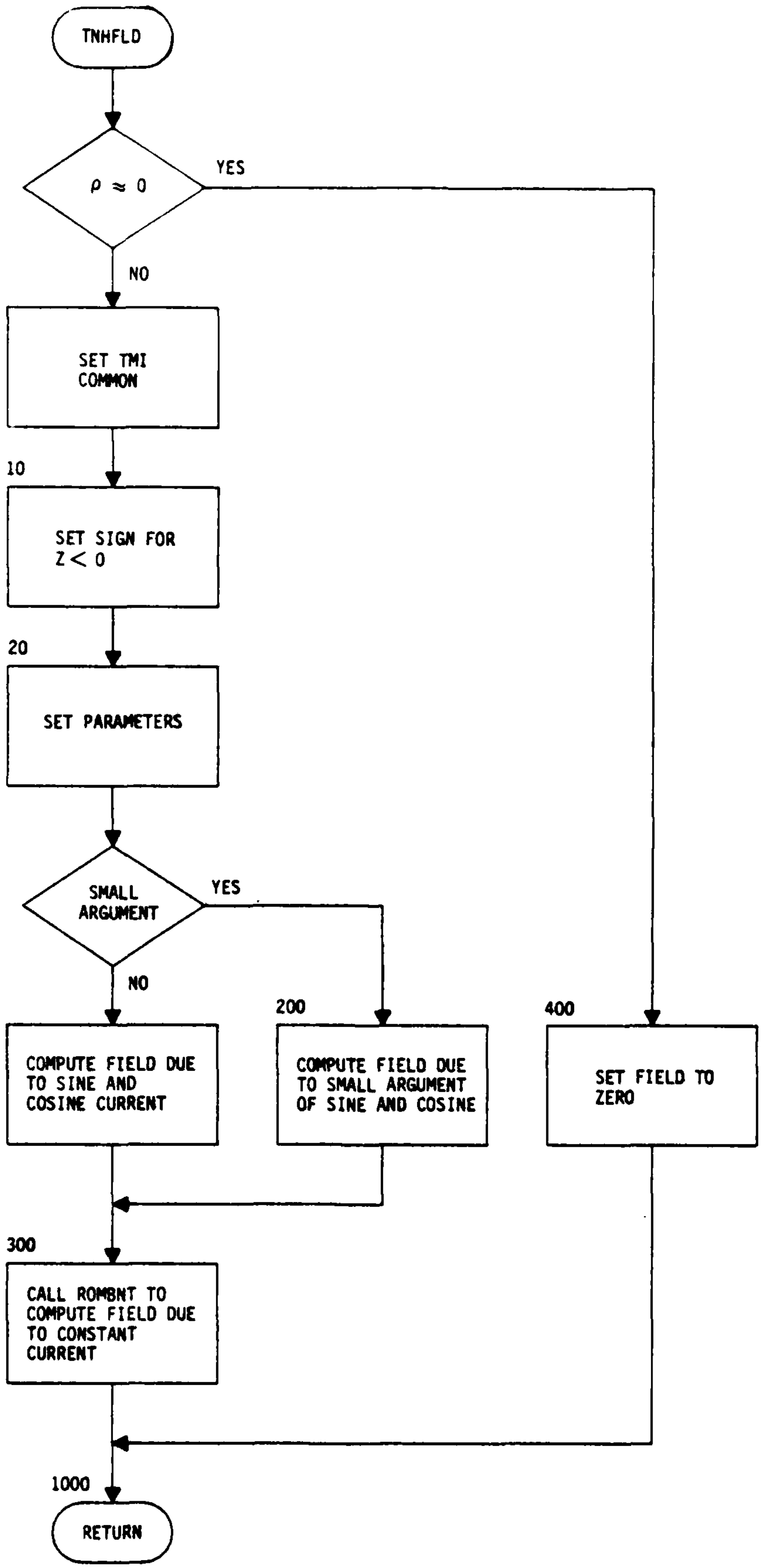
ASSIGN

ROMBNT

STATIN

STATOT

WLKBCK


TNHFLD
ρ ≈ 0
YES
NO
SET TMI COMMON
10
SET SIGN FOR Z < 0
20
SET PARAMETERS
SMALL ARGUMENT
YES
NO
200
400
COMPUTE FIELD DUE TO SINE AND COSINE CURRENT
COMPUTE FIELD DUE TO SMALL ARGUMENT OF SINE AND COSINE
SET FIELD TO ZERO
300
CALL ROMBNT TO COMPUTE FIELD DUE TO CONSTANT CURRENT
1000
RETURN

1. NAME: TPNFLD (GTD)

2. PURPOSE: To calculate the theta and phi unit vectors for the near-field observation direction.

3. METHOD: Vector algebra is used to compute the two unit vectors. Figure 1 shows the geometry required.

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
DP	Phi unit vector
DT	Theta unit vector
PH	Phi angle
TH	Theta angle

5. I/O VARIABLES:

A.	INPUT	LOCATION
	PH	F.P.
	TH	F.P.
B.	OUTPUT	LOCATION
	DP	F.P.
	DT	F.P.

6. CALLING ROUTINES:

DIFPLT	ENDIF	REFCYL
DPLRCL	RCLDPL	RPLDPL
DPLRPL	RCLRPL	RPLRCL
		SCLRPL

7. CALLED ROUTINE:

NONE

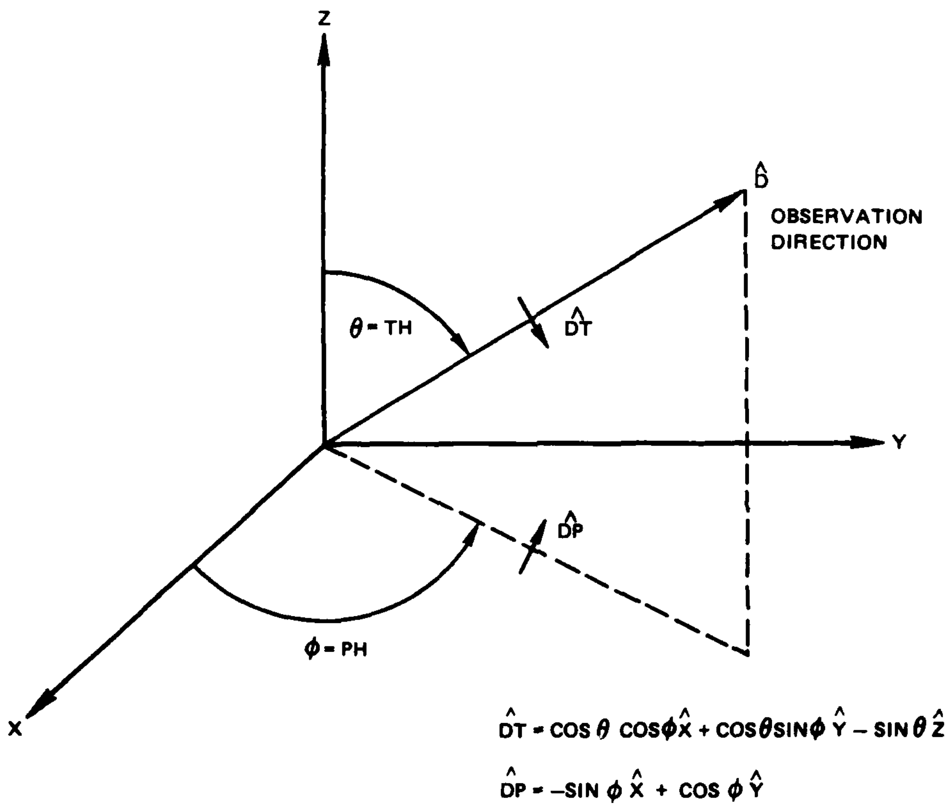
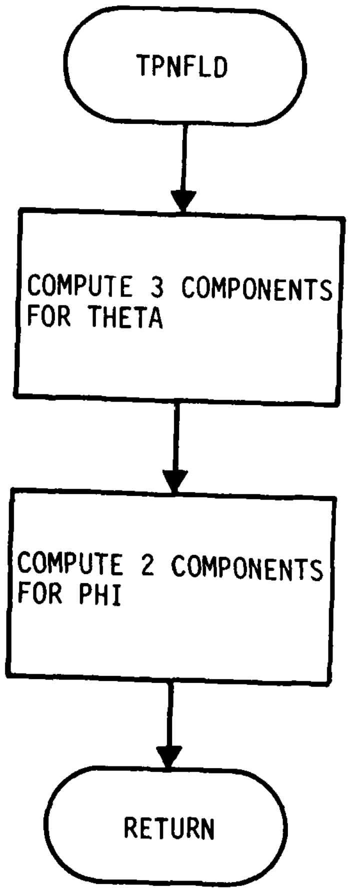


Figure 1. Illustration of The Theta ($\hat{DT}$) and Phi ($\hat{DP}$) Unit Vectors


TPNFLD
COMPUTE 3 COMPONENTS FOR THETA
COMPUTE 2 COMPONENTS FOR PHI
RETURN

1. NAME: TRCEBK (GTD, INPUT, MOM, OUTPUT)

2. PURPOSE: To print out the table of subroutines generated by WLKBCK for locating a fatal error.

3. METHOD: Prints out the table of subroutines called before the fatal error which was generated by WLKBCK. This table is contained in array NAMRTN and is indexed by INDXWB.

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
I1	Internal variable set to Hollerith name of subroutine for error output message
I2	Internal variable set to Hollerith name of subroutine for error output message
NAMSUB	Internal variable set to Hollerith name of subroutine

5. I/O VARIABLES:

A. INPUT

INPUT	LOCATION
INDXWB	/ADEBUG/
LUPRNT	/ADEBUG/
NAMRTN	/ADEBUG/

B. OUTPUT

OUTPUT	LOCATION
INDXWB	/ADEBUG/

6. CALLING ROUTINES:

ERROR

WLKBCK

7. CALLED ROUTINES:

NONE

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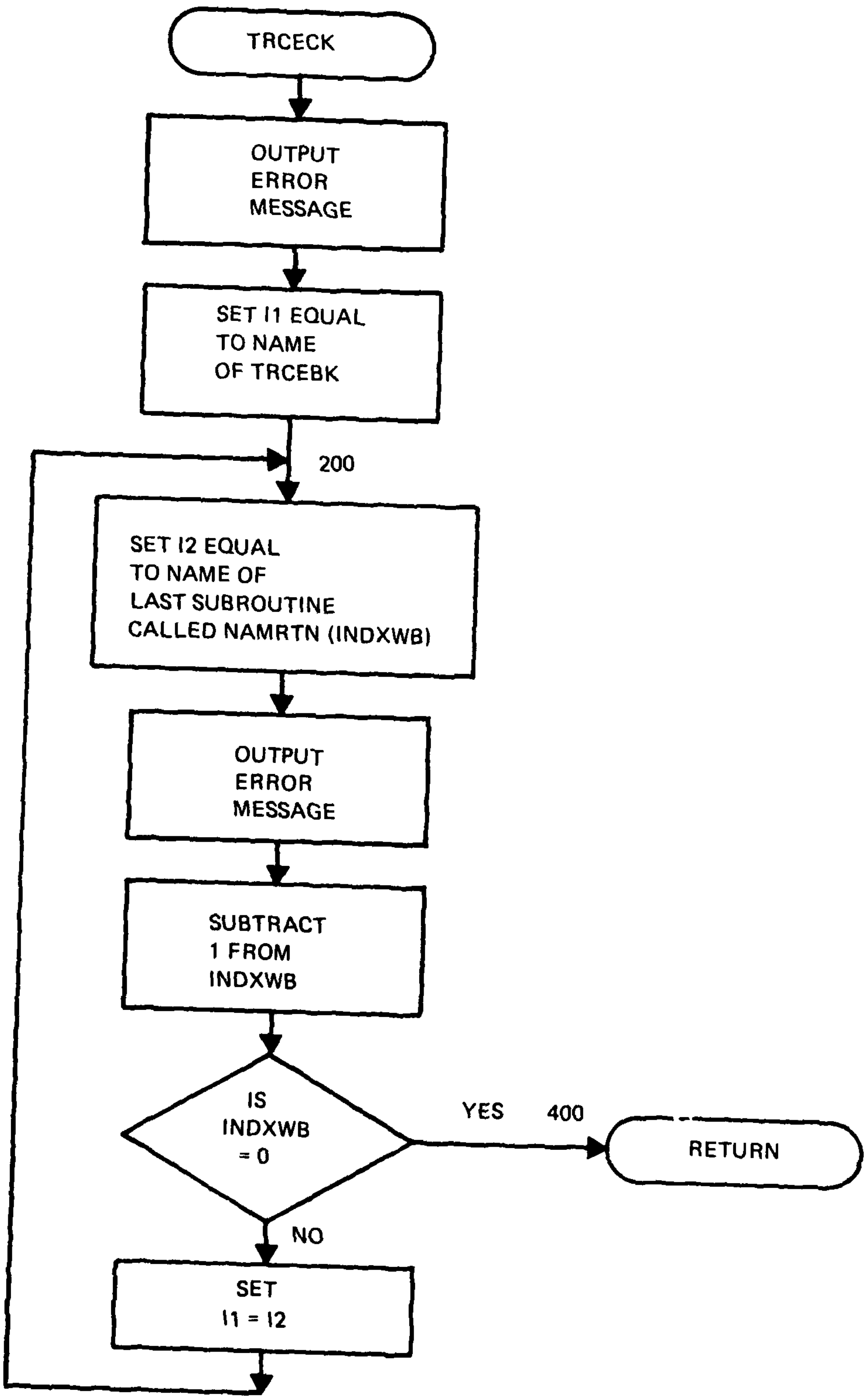
TRCEBK (GTD, INPUT, MOM, OUTPUT)



1. NAME: TRNLAT (INPUT)

2. PURPOSE: Translates a point to or from the origin of a coordinate system.

3. METHOD: The point is translated along its cartesian coordinate axes, and the operation code specifies whether it is a translation to or from the origin.

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
DX	The amount of the translation along x axis
DY	The amount of the translation along y axis
DZ	The amount of the translation along z axis
NOP	Translation operation code. If greater than zero, a translation to origin. If less than zero, a translation from the origin
X	Input/output of x coordinate
Y	Input/output of y coordinate
Z	Input/output of z coordinate

5. I/O VARIABLES:

A.

INPUT	LOCATION
DX	F.P.
DY	F.P.
DZ	F.P.
NOP	F.P.
X	F.P.
Y	F.P.
Z	F.P.

B. OUTPUT	LOCATION
X	F.P.
Y	F.P.
Z	F.P.

6. CALLING ROUTINES:

COORDS

WYRDRV

7. CALLED ROUTINES:

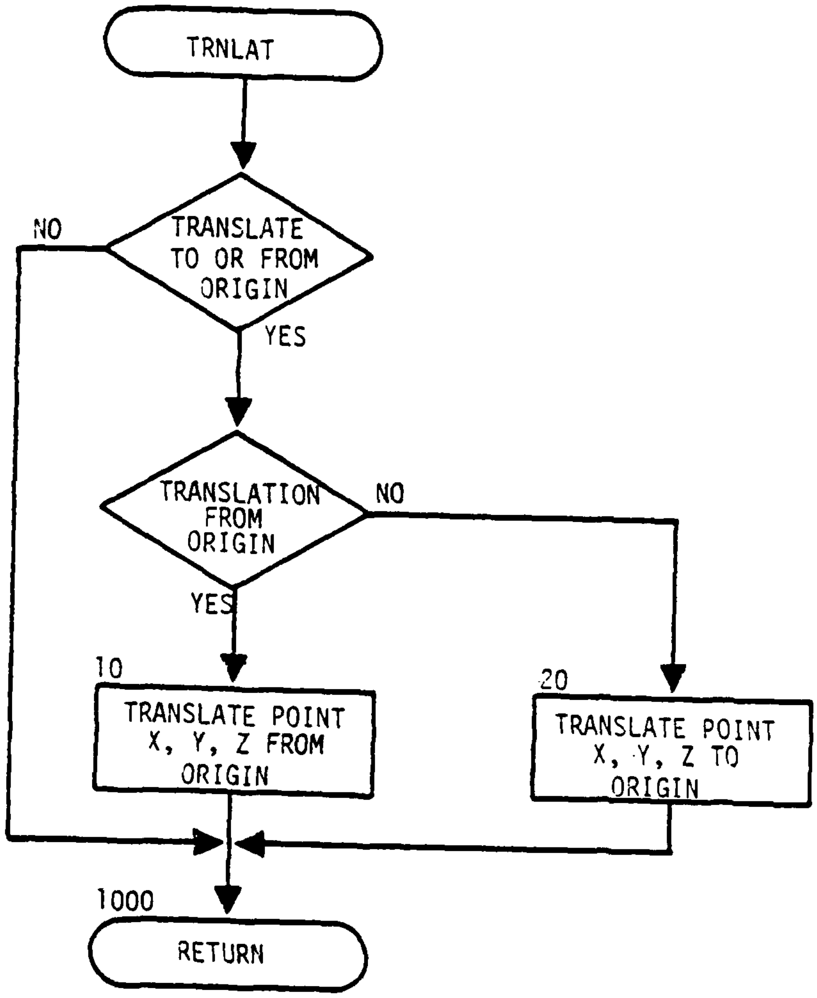
ASSIGN

STATIN

STATOT

WLKBCK

TRNLAT (INPUT)



1. NAME: TSKXQT (GTD)

2. PURPOSE: To read the task list and call the appropriate processors to execute the tasks.

3. METHOD: The task list is scanned twice: during the first scan the subroutines necessary to execute the tasks are called in order to initialize the required parameters. During the second pass the subroutines are called to perform the tasks as specified by the user.

Task execution normally begins with the first task in the task list and proceeds sequentially through the list unless a LABEL task is encountered. The LABEL task will redirect execution to its associated LOOP task until the required number of LOOP/LABEL loops has been fulfilled. Task execution terminates when an END command is encountered, the end of the task list is reached, or an error occurs in executing a task.

If the task list has been generated by a RSTART command, execution may not necessarily begin at the top of the task list. Normally, restart is begun from the task which wrote the checkpoint read in to generate the task list. In modules subsequent to the one which generated the checkpoint, execution can begin at the top of the task list (if the preceeding run did not complete its execution) or at the restart task (if execution was successfully completed).

The following tasks are active in the GTD module:

FORTRAN LABEL	TASK NAME	GTD MODULE FUNCTION
120	BACSUB	Link data set of solution vector to interaction matrix data set and identify it as a solution data set
130	BAND	Link banded matrix data set to full matrix data set
150	CHKPNT	Retrieve timed checkpoint parameters or write a command checkpoint
180	DEBUG	Turn off or on the debug flags
190	DECOMP	Link data sets of decomposed matrix to its parent data set
200	END	Terminate module execution

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END

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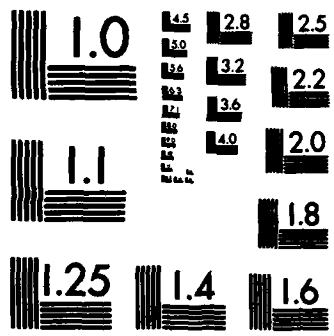


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

250	BMI	Link data set of solution vector to interaction matrix data set and identify it as a solution data set
260	LABEL	Decrement loop counter and branch to LOOP if positive
270	LOOP	Initialize loop counter
390	RESTRT	Process RSTART command error
410	SOLVE	Link solution to excitation and excitation to interaction matrices
440	WIPOUT	Process WIPOUT command error
480	GMDATA	Advance edition of geometry data set and reinitialize GTD geometry data
490	ZGEN	Call ZIJDRV to generate GTD interactions
530	EFIELD	Call FLDDRV to generate incident field matrix and scattered field Green's function matrix
540	DMP	Call DMPDRV to process direct manipulations
550	ESRC,VSRC	Call EXCDRV to generate GTD excitation
570	SETINT	Call SET to select GTD, MOM, and incident field interactions

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
CPFRWD	Checkpoint file rewind flag
DBGPRT	Debug print flag
DT	Time interval between calls to TICHEK
IBIT	Attribute word
IBITS	Attribute word for geometry data set
INCCHK	Checkpoint time increment

INDXA,INDXB, INDXC INDXG, INDXX	Pointer to symbol table entry for a data set
IOCKPT	Logical unit number of checkpoint file
ITASK	Pointer to task in task list being executed
JTASK	Internal variable equal to ITASK
KOUNT	The number of times the loop terminating on the reference label has been executed
LINDX	Index to the loop table entry currently being executed
LINKA	Pointer to data set linked to data set pointed to by INDXA
LOCARG	Pointer to task argument in NARGTB
LOCNXT	Pointer to NARGTB for the next task to be executed
LOCTP1	Pointer to first argument for a given task
LOCTSK	Location of task parameter in NARGTB
LSTARG	Location in argument list
LSTTPF	Pointer to last task executed for a restart job
LTRACE	Trace flag for debug
N	Loop index
NAMDAT	User-assigned name of geometry data set
NAMEB,NAMEC,NAMEX	User-assigned names of INTARG data sets
NAMGEO	Pointer to default geometry data set name in NCODES
NDX	Index to NCODES array for the task name mnemonic
NOP	No operation flag

NOSTAT	Logical flag set if statistics have not been requested
NPRREC	Number of words per geometry data set used
NT	Hollerith name of task
NUMARG	Number of INTARG arguments for a task
NUMTSK	Task identification number
NXTTSK	Pointer to the next task to be executed
TNOW	Current processor time
TRACST	Logical flag set if trace statistics are desired
YSSTAT	Logical flag set if statistics have been requested

5. I/O VARIABLES:

A. INPUT	LOCATION
CHKPNT	/SYSFIL/
CHKWRT	/SYSFIL/
COMPLT	/SYSFIL/
DBGPRT	/ADEBUG/
ISOFF	/ADEBUG/
ISON	/ADEBUG/
KBGEOM	/PARTAB/
KBREAL	/PARTAB/
KBSOLN	/PARTAB/
KOLBIT	/PARTAB/
KOLCNT	/PARTAB/
KOLCOL	/PARTAB/

KOLLNK	/PARTAB/
KOLNAM	/PARTAB/
KOLTIM	/PARTAB/
KOLTSK	/PARTAB/
KWOFF	/PARTAB/
KWON	/PARTAB/
KWSTAT	/PARTAB/
KWTRAC	/PARTAB/
LOOPMX	/PARTAB/
LSTTPF	/SYSFIL/
LUPRNT	/ADEBUG/
MAXBLK	/SEGMNT/
MAXSEG	/SEGMNT/
MXARGS	/ARGCOM/
NAMTSK	/PARTAB/
NARGTB	/PARTAB/
NCODES	/PARTAB/
NDATBL	/PARTAB/
NLOOPS	/PARTAB/
NOGOFG	/ADEBUG/
NOPCOD	/ADEBUG/
NOSTAT	/ADEBUG/
NPRSEG	/PARTAB/
NPTASK	/SEGMNT/
NTINT	/ADEBUG/

NTSKTB	/PARTAB/
NXTTSK	/ADEBUG/
RSTART	/SYSFIL/
RSTRTA	/SYSFIL/

B. OUTPUT — LOCATION

OUTPUT	LOCATION
CHKWRT	/SYSFIL/
CPFRWD	/SYSFIL/
DBGPRT	/ADEBUG/
IERRF	/ADEBUG/
INCCHK	/SYSFIL/
INTARG	/ARGCOM/
IOCKPT	/SYSFIL/
IPASS	/ADEBUG/
LSTTPF	/SYSFIL/
MAXBLK	/SEGMNT/
NOGOFG	/ADEBUG/
NOSTAT	/ADEBUG/
NUMARG	/ARGCOM/
NXTTSK	/ADEBUG/
RSTART	/SYSFIL/

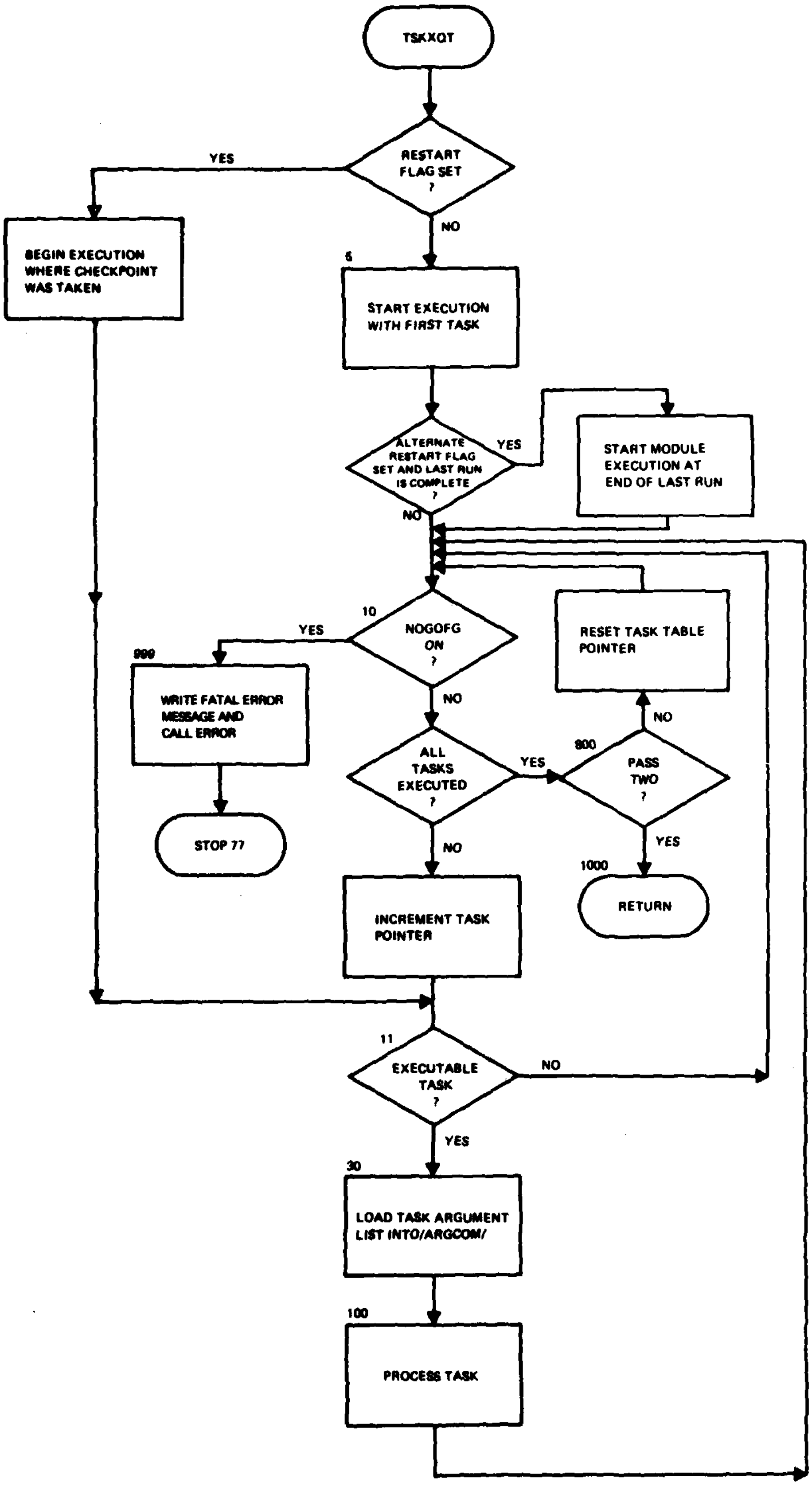
6. CALLING ROUTINE:

GEMACS

7. CALLED ROUTINES:

ASSIGN	GETGEO	SYSCHK
CONVRT	GTDDRV	TICHEK
DMPDRV	SET	WLKBCK
ERROR	STATIN	WRTCHK
EXCDRV	STATOT	ZIJDRV
FLDDRV	SYMDEF	
GETARG	SYMUPD	

TSKXQT (GTD)



TSKXQT
RESTART FLAG SET ?
YES
NO
BEGIN EXECUTION WHERE CHECKPOINT WAS TAKEN
6
START EXECUTION WITH FIRST TASK
ALTERNATE RESTART FLAG SET AND LAST RUN IS COMPLETE ?
YES
NO
START MODULE EXECUTION AT END OF LAST RUN
10
NOGOFG ON ?
YES
999
WRITE FATAL ERROR MESSAGE AND CALL ERROR
STOP 77
RESET TASK TABLE POINTER
NO
ALL TASKS EXECUTED ?
YES
800
PASS TWO ?
NO
YES
1000
RETURN
NO
INCREMENT TASK POINTER
11
EXECUTABLE TASK ?
NO
YES
30
LOAD TASK ARGUMENT LIST INTO/ARGCOM/
100
PROCESS TASK

1. NAME: TSKXQT (INPUT)

2. PURPOSE: To read the task list and call the appropriate processors to execute the tasks.

3. METHOD: The task list is scanned twice: during the first scan the subroutines necessary to execute the tasks are called in order to initialize the required parameters. During the second pass the subroutines are called to perform the tasks as specified by the user.

Task execution normally begins with the first task in the task list and proceeds sequentially through the list unless a LABEL task is encountered. The LABEL task will redirect execution to its associated LOOP task until the required number of LOOP/LABEL loops has been fulfilled. Task execution terminates when an END command is encountered, the end of the task list is reached, or an error occurs in executing a task.

If the task list has been generated by a RSTART command, execution may not necessarily begin at the top of the task list. Normally, restart is begun from the task which wrote the checkpoint read in to generate the task list. In modules subsequent to the one which generated the checkpoint, execution can begin at the top of the task list (if the preceding run did not complete its execution) or at the restart task (if execution was successfully completed).

The following tasks are active in the INPUT module:

FORTRAN LABEL	TASK NAME	INPUT MODULE FUNCTION
120	BACSUB	Link data set of solution vector to data set of interaction matrix
130	BAND	Link banded matrix data set to full matrix data set
150	CHKPNT	Recover the checkpoint file rewind flag
180	DEBUG	Turn off or on the debug flags
190	DECOMP	Link data sets of decomposed matrix to its parent data set
200	END	Terminate module execution
230	INPUT	Call GEODRV to process input data

250	BMI	Link data set of solution vector to data set of interaction matrix
260	LABEL	Decrement loop counter and branch to LOOP if positive
270	LOOP	Initialize loop counter
390	RESTRT	Process RSTART command error
410	SOLVE	Link data set of solution vector to data set of interaction matrix
440	WIPOUT	Process WIPOUT command error
480	GiMDATA	Call GEODRV to process geometry input
490	ZGEN	Link data set of interaction matrix to geometry data set
530	EFIELD	Call EFDGEO to assure that EFIELD argument is linked to geometry data set
540	DMP	Call DMPDRV to process direct manipulations
550	ESRC,VSRC	Link data set of excitation vector to geometry data set

4. INTERNAL VARIABLES:

VARIABLE	DEFINITION
CPFRWD	Checkpoint file rewind flag
DBGPRT	Debug print flag
DT	Time interval between calls to TICHEK
INDEX	Pointer to geometry data set
INDXA,INDXB,INDXX	Pointer to symbol table entry for a data set
IOCKPT	Logical unit number of checkpoint file
ISAV2	Temporary storage for argument 2 of INTARG array

ISAV3	Temporary storage for argument 3 of INTARG array
ITASK	Pointer to task in task list being executed
KOUNT	The number of times the loop terminating on the reference label has been executed
LINDX	Index to the loop table entry currently being executed
LINKA	Pointer to data set linked to data set pointed to by INDXA
LOCARG	Pointer to task argument in NARGTB
LOCNXT	Pointer to NARGTB for the next task to be executed
LOCTP1	Pointer to first argument for a given task
LOCTSK	Location of task parameter in NARGTB
LSTARG	Location in argument list
LSTTPF	Pointer to last task executed for a restart job
LTRACE	Trace flag for debug
N	Loop index
NAMEA,NAMEB,NAMEX	User-assigned names of INTARG data sets
NAMGEO	Pointer to default geometry data set name in NCODES
NDX	Index to NCODES array for the task name mnemonic
NOP	No operation flag
NOSTAT	Logical flag set if statistics have not been requested
NPRREC	Number of words per geometry data set record
NT	Hollerith name of task

NUMARG	Number of INTARG arguments for a task
NUMTSK	Task identification number
NXTTSK	Pointer to the next task to be executed
TNOW	Current processor time
TRACST	Logical flag set if trace statistics are desired
YSSTAT	Logical flag set if statistics have been requested

5. I/O VARIABLES:

A. INPUT

INPUT	LOCATION
CHKWRT	/SYSFIL/
COMPLT	/SYSFIL/
DBGPRT	/ADEBUG/
ISOFF	/ADEBUG/
ISON	/ADEBUG/
KOLCNT	/PARTAB/
KOLLNK	/PARTAB/
KOLNAM	/PARTAB/
KOLTIM	/PARTAB/
KOLTSK	/PARTAB/
KWGEOM	/PARTAB/
KWNAME	/PARTAB/
KWOFF	/PARTAB/
KWON	/PARTAB/
KWSTAT	/PARTAB/

KWTRAC	/PARTAB/
LOOPMX	/PARTAB/
LSTTPF	/SYSFIL/
LUPRNT	/ADEBUG/
MXARGS	/ARGCOM/
NAMTSK	/PARTAB/
NARGTB	/PARTAB/
NCODES	/PARTAB/
NDATBL	/PARTAB/
NLOOPS	/PARTAB/
NOGOFG	/ADEBUG/
NOPCOD	/ADEBUG/
NOSTAT	/ADEBUG/
NPTASK	/PARTAB/
NTSKTB	/PARTAB/
NXTTSK	/ADEBUG/
RSTART	/SYSFIL/
RSTRTA	/SYSFIL/

B. OUTPUT LOCATION

CHKPNT	/SYSFIL/
CHKWRT	/SYSFIL/
CPFRWD	/SYSFIL/
DBGPRT	/ADEBUG/
IERRF	/ADEBUG/
INTARG	/ARGCOM/
IOCKPT	/SYSFIL/

IPASS	/ADEBUG/
LSTTPF	/SYSFIL/
LTRACE	/ADEBUG/
NOSTAT	/ADEBUG/
NUMARG	/ARGCOM/
RSTART	/SYSFIL/
TRACST	/ADEBUG/

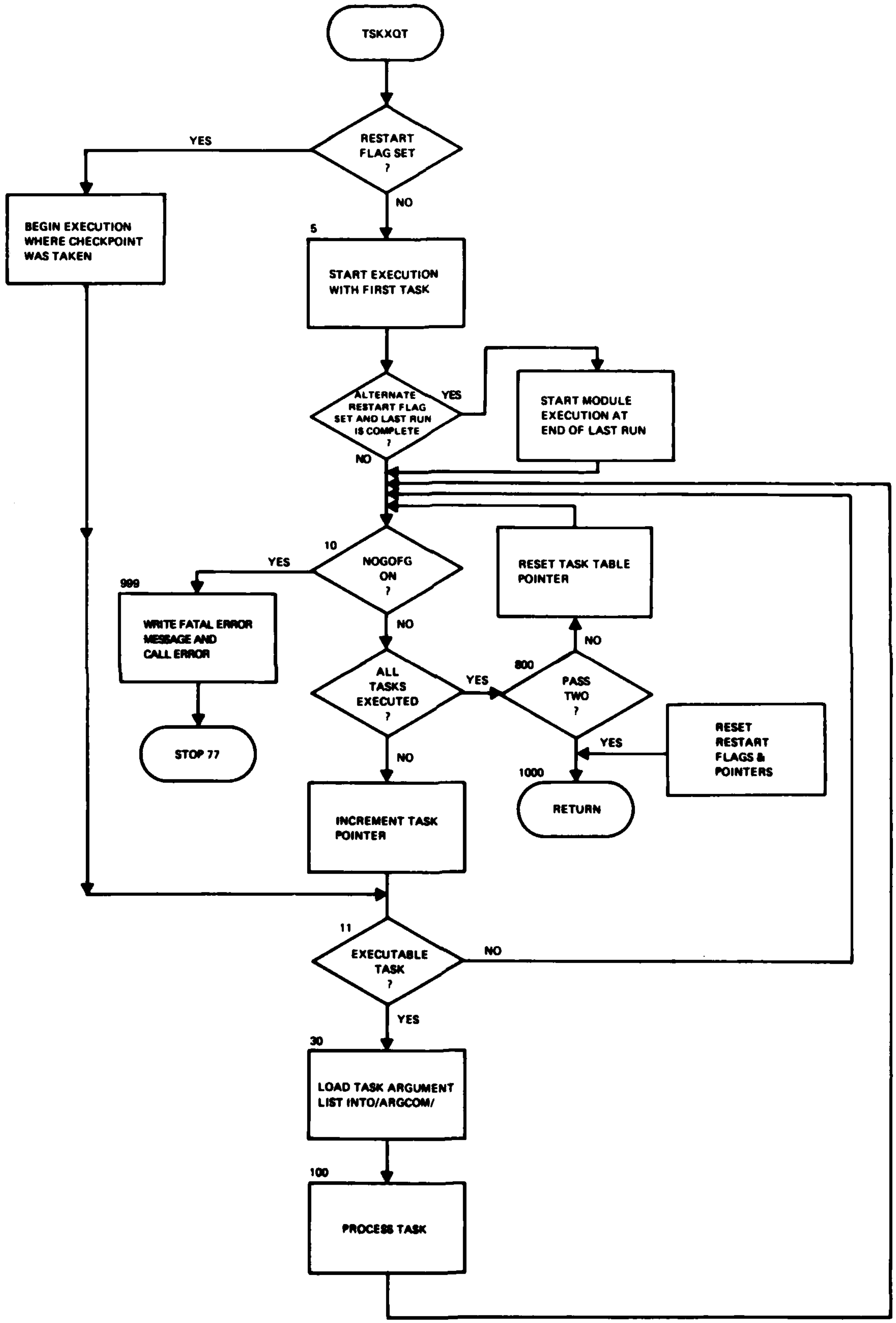
6. CALLING ROUTINE:

GEMACS

7. CALLED ROUTINES:

ASSIGN	STATIN
CONVRT	STATOT
DMPDRV	SYMUPD
EFDGEO	SYSCHK
ERROR	TICHEK
GEODRV	WLKBCK
	ZZXDUM

TSKXQT (INPUT)



1. NAME: TSKXQT (MOM)

2. PURPOSE: To read the task list and call the appropriate processor to execute the tasks.

3. METHOD: The task list is scanned twice: during the first scan the subroutines necessary to execute the tasks are called in order to initialize the required parameters. During the second pass the subroutines are called to perform the tasks as specified by the user.

   Task execution normally begins with the first task in the task list and proceeds sequentially through the list unless a LABEL task is encountered. The LABEL task will redirect execution to its associated LOOP task until the required number of LOOP/LABEL loops has been fulfilled. Task execution terminates when an END command is encountered, the end of the task list is reached, or an error occurs in executing a task.

   If the task list has been generated by a RSTART command, execution may not necessarily begin at the top of the task list. Normally, restart is begun from the task which wrote the checkpoint read in to generate the task list. In modules subsequent to the one which generated the checkpoint, execution can begin at the top of the task list (if the preceeding run did not complete its execution) or at the restart task (if execution was successfully completed).

   The following tasks are active in the MOM module.

FORTRAN LABEL	TASK NAME	MOM MODULE FUNCTION
120	BACSUB	Call SOLDRV to back substitute to find solution vector
130	BAND	Call BANDIT to band a matrix
150	CHKPNT	Retrieve timed checkpoint parameters or write a command checkpoint
180	DEBUG	Turn off or on the debug flags
190	DECOMP	Call LUDDRV to decompose matrix into upper and lower triangular matrices
200	END	Terminate module execution
250	BMI	Call SOLDRV to perform banded matrix iteration

260	LABEL	Decrement loop counter and branch to LOOP if positive
270	LOOP	Initialize loop counter
310	WRITE	Call PRTSYM to write symbol data to output file
340	PRINT	Call PRTSYM to write symbol data to output file
350	PURGE	Purge symbol from NDATBL and close data file
390	RESTART	Process RSTART command error
400	SET	Call SETDRV to set data set entries
410	SOLVE	Call LUDDRV and SOLDRV to obtain solution vector
440	WIPOUT	Process WIPOUT command error
460	ZSET	Call SETDRV
480	GMDATA	Advance edition of geometry data set
490	ZGEN	Call ZIJDRV to generate MOM interaction matrix
520	ZLOADS	Call LODDRV to generate load vector
530	EFIELD	Call FLDDRV to generate total field from incident and scattered fields
540	DMP	Call DMPDRV to process direct manipulations
550	ESRC, VSRC	Call EXCDRV to generate MOM excitation
570	SETINT	Call SET to select GTD, MOM, and incident field interactions

4. **INTERNAL VARIABLES:**

VARIABLE	DEFINITION
CPFRWD	Checkpoint file rewind flag
DBGPRT	Debug print flag

DT	Time interval between calls to TICHEK
I	Loop index
IBITS	Attribute word for geometry data set
INCCHK	Checkpoint time increment
INDXG	Pointer to symbol table entry for a data set
IOCKPT	Logical unit number of checkpoint file
ISAV2	Temporary storage for argument 2 of INTARG array
ISAV3	Temporary storage for argument 3 of INTARG array
ITASK	Pointer to task in task list being executed
KOUNT	The number of times the loop terminating on the reference label has been executed
LINDX	Index to the loop table entry currently being executed
LOCARG	Pointer to task argument in NARGTB
LOCFIL	Logical file associated with symbol to be purged
LOCNXT	Pointer to NARGTB for the next task to be executed
LOCSYM	Location pointer for a symbol name
LOCTP1	Pointer to first argument for a given task
LOCTP2	Pointer to second argument for a given task
LOCTSK	Location of task parameters in NARGTB
LSTARG	Location in argument list
LSTTPF	Points to last task executed for a restart job
LTRACE	Trace flag for debug

N	Loop index
NAMDAT	User-assigned name of geometry data set
NAMGEO	Pointer to default geometry data set name in NCODES
NDX	Index to NCODES array for the task name mnemonic
NOP	No operation flag
NOSTAT	Logical flag set if statistics have not been requested
NPRREC	Number of words for geometry data set record
NT	Hollerith name of a task
NUMARG	Number of INTARG arguments for a task
NUMTSK	Task identification number
NXTTSK	Pointer to the next task to be executed
TNOW	Current processor time
TRACST	Locical flag set if trace statistics are desired
YSSTAT	Logical flag set if statistics have been requested

I/O VARIABLES:

A. INPUT	LOCATION
CHKWRT	/SYSFIL/
COMPLT	/SYSFIL/
DBGPRT	/ADEBUG/
ISOFF	/ADEBUG/
ISON	/ADEBUG/
KBGEOM	/PARTAB/

KBREAL	/PARTAB/
KOLCNT	/PARTAB/
KOLCOL	/PARTAB/
KOLLOC	/PARTAB/
KOLNAM	/PARTAB/
KOLTIM	/PARTAB/
KOLTSK	/PARTAB/
KWOFF	/PARTAB/
KWON	/PARTAB/
KWSTAT	/PARTAB/
KWTRAC	/PARTAB/
LSTTPF	/SYSFIL/
LOOPMX	/PARTAB/
LUPRNT	/ADEBUG/
MAXBLK	/SEGMNT/
MAXSEG	/SEGMNT/
MXARGS	/ARGCOM/
NAMTSK	/PARTAB/
NARGTB	/PARTAB/
NCODES	/PARTAB/
NDATBL	/PARTAB/
NLOOPS	/PARTAB/
NOGOFG	/ADEBUG/
NOPCOD	/ADEBUG/
NOSTAT	/ADEBUG/

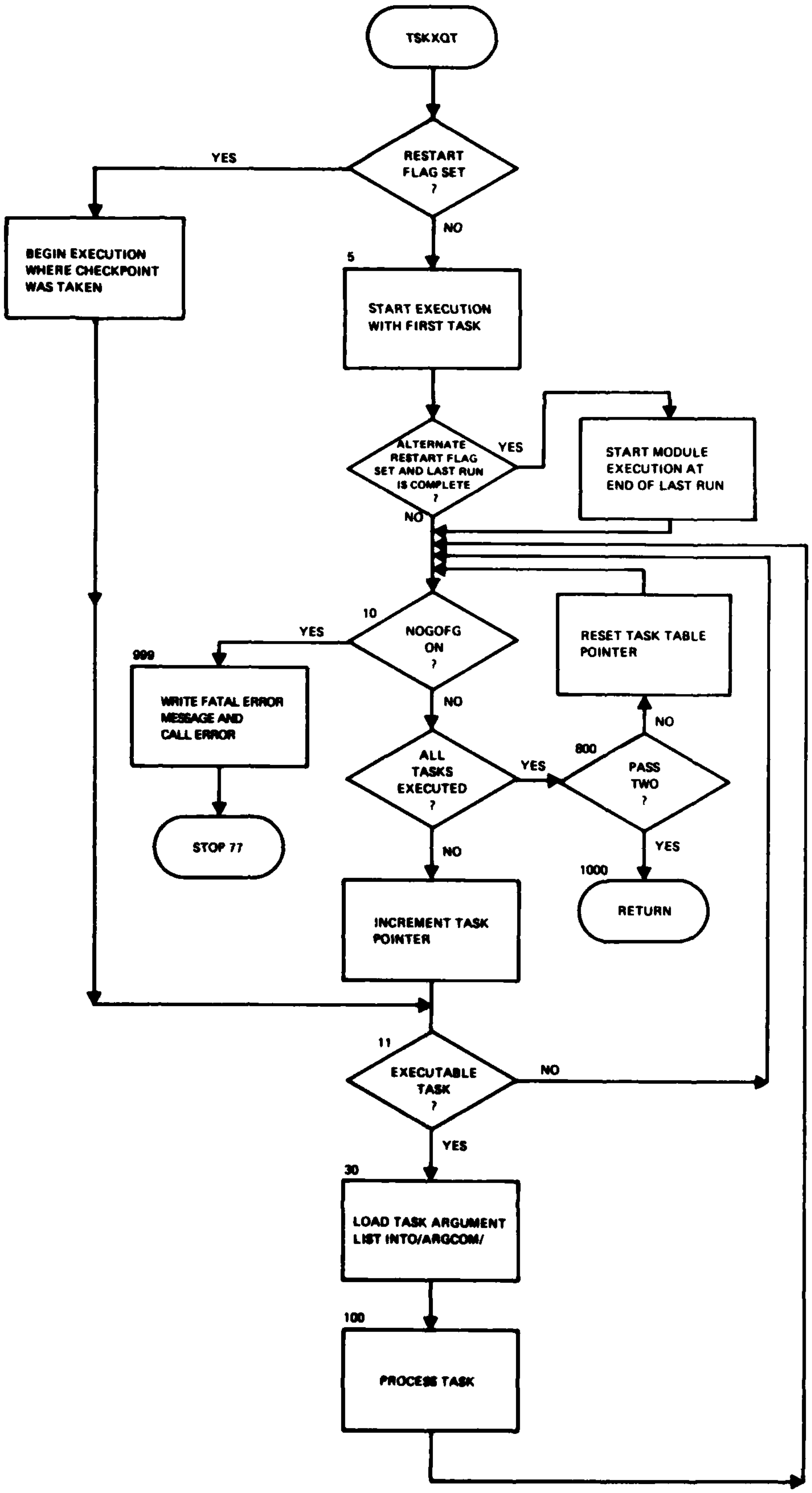
	NPRSEG	/SEGMNT/
	NPTASK	/PARTAB/
	NTINT	/ADEBUG/
	NTSKTB	/PARTAB/
	NXTTSK	/ADEBUG/
	RSTART	/SYSFIL/
	RSTRTA	/SYSFIL/
B.	OUTPUT	LOCATION
	CHKPNT	/SYSFIL/
	CHKWRT	/SYSFIL/
	CPFRWD	/SYSFIL/
	DBGPRT	/ADEBUG/
	IERRF	/ADEBUG/
	INCCHK	/SYSFIL/
	INTARG	/ARGCOM/
	IOCKPT	/SYSFIL/
	IPASS	/ADEBUG/
	LSTTPF	/SYSFIL/
	LTRACE	/SYSFIL/
	MAXBLK	/SEGMNT/
	NOGOFG	/ADEBUG/
	NOSTAT	/ADEBUG/
	NUMARG	/ARGCOM/
	NXTTSK	/ADEBUG/
	RSTART	/SYSFIL/

6. CALLING ROUTINE:

GEMACS

7. CALLED ROUTINES:

ASSIGN	EXCDRV	OPNFIL	STATOT	WRTCHK
BANDIT	FLDDRV	PRTSYM	SYMDEF	ZCDRVR
CLSFIL	GETARG	SET	SYMUPD	ZIJDRV
CONVRT	GETGEO	SETDRV	SYSCHK	ZZXDUM
DMPDRV	LODDRV	SOLDRV	TICHEK	
ERROR	LUDDRV	STATIN	WLKBCK	


TSKXQT
RESTART FLAG SET ?
YES
NO
BEGIN EXECUTION WHERE CHECKPOINT WAS TAKEN
5
START EXECUTION WITH FIRST TASK
ALTERNATE RESTART FLAG SET AND LAST RUN IS COMPLETE ?
YES
START MODULE EXECUTION AT END OF LAST RUN
NO
10
NOGOFG ON ?
YES
999
WRITE FATAL ERROR MESSAGE AND CALL ERROR
STOP 77
RESET TASK TABLE POINTER
NO
ALL TASKS EXECUTED ?
YES
800
PASS TWO ?
NO
YES
1000
RETURN
NO
INCREMENT TASK POINTER
11
EXECUTABLE TASK ?
NO
YES
30
LOAD TASK ARGUMENT LIST INTO/ARGCOM/
100
PROCESS TASK

1. NAME: TSKXQT (OUTPUT)

2. PURPOSE: To read the task list and call the appropriate processor to execute the tasks.

3. METHOD: The task list is scanned twice: during the first scan the subroutines necessary to execute the tasks are called in order to initialize the required parameters. During the second pass the subroutines are called to perform the tasks as specified by the user.

   Task execution normally begins with the first task in the task list and proceeds sequentially through the list unless a LABEL task is encountered. The LABEL task will redirect execution to its associated LOOP task until the required number of LOOP/LABEL loops has been fulfilled. Task execution terminates when an END command is encountered, the end of the task list is reached, or an error occurs in executing a task.

   If the task list has been generated by a RSTART command, execution may not necessarily begin at the top of the task list. Normally, restart is begun from the task which wrote the checkpoint read in to generate the task list. In modules subsequent to the one which generated the checkpoint, execution can begin at the top of the task list (if the preceeding run did not complete its execution) or at the restart task (if execution was successfully completed).

   The following tasks are active in the OUTPUT module:

FORTRAN LABEL	TASK NAME	OUTPUT MODULE FUNCTION
150	CHKPNT	Retrieve timed checkpoint parameters or write a command checkpoint
180	DEBUG	Turn off or on the debug flags
200	END	Terminate module execution
260	LABEL	Decrement loop counter and branch to LOOP if positive
270	LOOP	Initialize loop counter
390	RESTART	Process RSTART command error
440	WIPOUT	Process WIPOUT command error
480	GMDATA	Advance edition of geometry data set

530	EFIELD	Call FLDDRV to print and plot scattered and incident fields
540	DMP	Call DMPDRV to process direct manipulations
570	SETINT	Call SET to select GTD, MOM, and incident field interactions

When the OUTPUT module execution is complete, the alternate restart flag is turned off and the pointer to the last task executed is set to the last task of the run.

4. INTERNAL VARIABLES:

VARIABLE	DESCRIPTION
CPFRWD	Checkpoint file rewind flag
DBGPRT	Debug print flag
DT	Time interval between calls to TICHEK
IBITS	Attribute word for geometry data set
INCCHK	Checkpoint time increment
INDXG	Pointer to symbol table entry for a data set
IOCKPT	Logical unit number of checkpoint file
ITASK	Pointer to task in task list being executed
KOUNT	The number of times the loop terminating on the reference label has been executed
LINDX	Index to the loop table entry currently being executed
LOCARG	Pointer to task argument in NARGTB
LOCNXT	Pointer to NARGTB for the next task to be executed
LOCTP1	Pointer to first argument for a given task
LOCTSK	Location of task parameters in NARGTB

LSTARG	Location in argument list
LSTTPF	Pointer to last task executed for a restart job
LTRACE	Trace flag for debug
N	Loop index
NAMDAT	User-assigned name of geometry data set
NAMGEO	Pointer to default geometry data set name in NCODES
NDX	Index to NCODES array for the task name mnemonic
NOP	No operation flag
NPRREC	Number of words per geometry data set record
NOSTAT	Logical flag set if statistics have not been requested
NT	Hollerith name of a task
NUMARG	Number of INTARG arguments for a task
NUMTSK	Task identification number
NXTTSK	Pointer to the next task to be executed
TNOW	Current processor time
TRACST	Logical flag set if trace statistics are desired
YSSTAT	Logical flag set if statistics have been requested

5. I/O VARIABLES:

A. INPUT	LOCATION
CHKWRT	/SYSFIL/
COMPLT	/SYSFIL/
DBGPRT	/ADEBUG/

TSKXQT (OUTPUT)

ISOFF	/ADEBUG/
ISON	/ADEBUG/
KBGEOM	/PARTAB/
KBREAL	/PARTAB/
KOLCNT	/PARTAB/
KOLCOL	/PARTAB/
KOLNAM	/PARTAB/
KOLTIM	/PARTAB/
KOLTSK	/PARTAB/
KWOFF	/PARTAB/
KWON	/PARTAB/
KWSTAT	/PARTAB/
KWTRAC	/PARTAB/
LOOPMX	/PARTAB/
LSTTPF	/SYSFIL/
LUPRNT	/ADEBUG/
MAXBLK	/SEGMNT/
MAXSEG	/SEGMNT/
MXARGS	/ARGCOM/
NAMTSK	/PARTAB/
NARGTB	/PARTAB/
NCODES	/PARTAB/
NDATBL	/PARTAB/
NLOOPS	/PARTAB/
NOGOFG	/PARTAB/

NOGOFG	/ADEBUG/
NOPCOD	/ADEBUG/
NOSTAT	/ADEBUG/
NPRSEG	/SEGMNT/
NPTASK	/PARTAB/
NTINT	/ADEBUG/
NTSKTB	/PARTAB/
NXTTSK	/ADEBUG/
RSTART	/SYSFIL/
RSTRTA	/SYSFIL/

B. OUTPUT LOCATION

CHKPNT	/SYSFIL/
CHKWRT	/SYSFIL/
COMPLT	/SYSFIL/
CPFRWD	/SYSFIL/
DBGPRT	/ADEBUG/
IERRF	/ADEBUG/
INCCHK	/SYSFIL/
INTARG	/ARGCOM/
IOCKPT	/SYSFIL/
IPASS	/ADEBUG/
LSTTPF	/SYSFIL/
MAXBLK	/SEGMNT/
NOGOFG	/ADEBUG/
NOSTAT	/ADEBUG/

NUMARG	/ARGCOM/
NXTTSK	/ADEBUG/
RSTART	/SYSFIL/
RSTRTA	/SYSFIL/

6. CALLING ROUTINE:

   GEMACS

7. CALLED ROUTINES:

   ASSIGN

   CONVRT

   DMPDRV

   ERROR

   FLDDRV

   GETARG

   GETGEO

   SET

   STATIN

   STATOT

   SYMDEF

   SYMUPD

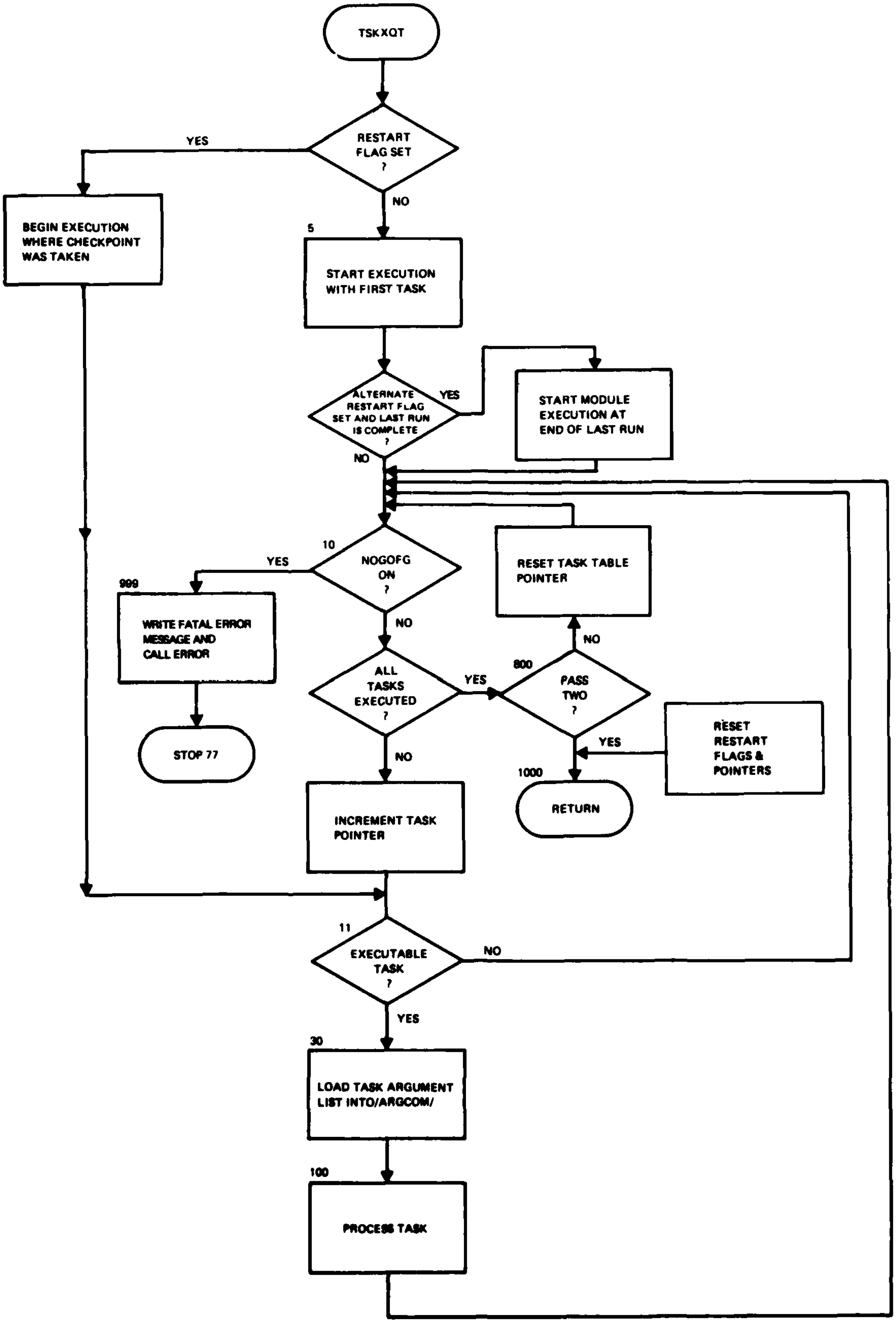
   SYSCHK

   TICHEK

   WLKBCK

   WRTCHK

TSKXQT (OUTPUT)



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END

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